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INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mī'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'co
10^{-15}	femto	f	fĕm'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 6, June 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
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Environmental Control Administration • Bureau of Radiological Health

Reports

Preliminary Results of Surveys of 5,263 Medical X-ray Facilities 1962-1967[1]

Bureau of Radiological Health[2]

Preliminary results of State surveys of 5,263 facilities with medical x-ray equipment are presented. Parameters such as equipment type and operating characteristics, personnel protection, workload, and certain aspects of operating technique were studied over a period, from 1962 to 1967. The results of these studies will be considered together with other studies now in preparation, and it is possible that some of the findings will be changed when the data are further evaluated.

As of June 30, 1967, data from surveys of 5,263 facilities with medical x-ray equipment were available for retrieval from magnetic-tape records. These surveys were performed by personnel of 25 States and 2 territories, and covered the period 1967 to 1967. Eight States, 1 territory and the District of Columbia contributed less than 100 surveys each. They are Alaska, Indiana, Iowa, Ohio, Pennsylvania, Utah, Vermont and the Virgin Islands. Seventeen States and 1 territory contributed 100 or more surveys each. They are Alabama, Arkansas, Colorado, Kansas, Kentucky, Maine, Maryland, Massachusetts, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, Oregon, Rhode Island, Washington, and Puerto Rico. The survey data were collected on standardized forms supplied by the Public Health Service. From this information frequency distributions on selected items of interest were produced. The frequency distributions tabulated in this report are designed to permit comparisons between healing arts specialties which provide the largest homogeneous, mutually exclusive subsamples.

Attention is directed to certain aspects of the preliminary findings listed in the tables.

1. The "total" columns do not represent the sums of the numbers given for the specialties listed under type of facility or type of practice. The reason is that many categories provided subsamples that were too small to permit comparison with the larger groups identified in the tables, but still constituted part of the facilities or practices with medical x-ray equipment.

2. In many tables a large percentage of entries are designated "unknown," largely because some participating States do not require the specific items of information to be collected as part of their survey programs.

3. The "card information" reported in the tables refers to the data appearing on the facility form,

[1] This report presents preliminary results which, together with findings of other studies currently available to the Bureau of Radiological Health, will be critically reviewed for reporting to Congress under Public Law 90-602, as required, by January 1, 1970. The report to Congress, now in preparation, will critically evaluate the information and it is possible that some of the data will be changed or deleted should analysis of the data indicate that such change or deletion is appropriate, based on statistical or related considerations.

[2] Extracted from Radiation Control for Health and Safety Act of 1967, Hearings before the Committee on Commerce, United States Senate, 90th Congress, 2nd session on S20, 67, S3211, H.R. 10790, Part 2 (May 6, 8, 9, 13, 15, 1968) p. 1075. Prepared by Lawrence R. Fess and Lavert C. Seabron.

the radiographic form, and the fluoroscopic form, making up the X-ray Protection Survey Report. Each form used has a corresponding IBM card. Hence the use in the tables of the term "facility card information", "radiographic card information" etc. A radiographic-fluoroscopic unit will have more than one card, each related to a different use of the machine. Details about the forms and cards have been published (*1*).

This report attempts to provide a systematic approach to the analysis of the data. The effort is to provide: (a) a profile of the "average" medical diagnostic x-ray facility as obtained from the particular sample surveyed—bearing in mind that none of the averages or ratios in any of the columns is typical of the specialties except by chance, and (b) indications of either conformance with, or deviations from, accepted practice with respect to specific items considered in the survey.

Personnel, workload, and equipment. In table 1, data presented by type of practice and type of facility reveal that the number of persons (including those occupationally exposed, x-ray machine operators, and those monitored), as well as the quantity of equipment, is related to patient workload. As expected, the workload is greatest in hospitals, radiologists' offices, and clinics.

Table 1. Personnel, workload, and equipment from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Facility data	Type of facility or type of practice										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Personnel:											
Average number of personnel occupationally exposed	4.3	2.4	2.0	2.1	2.5	1.6	3.4	3.7	5.0	1.2	2.5
Average number of x-ray machine operators	3.7	1.9	1.7	1.8	1.8	1.5	2.6	2.8	4.2	1.1	2.1
Average number of personnel monitored	3.2	.5	.1	.2	.7	.1	.8	1.3	3.9	.1	1.0
Workload: (average number of patients per week per facility)											
Radiographed	143.2	15.4	6.2	17.9	37.1	4.3	31.4	133.3	120.9	4.4	47.4
Fluoroscoped	18.8	5.6	3.3	5.0	8.0	4.2	3.8	12.0	18.0	3.0	11.3
Equipment: (average number per facility)											
X-ray machines	2.0	1.1	1.0	1.0	1.0	1.0	1.1	1.2	3.0	1.0	1.36
X-ray tubes	3.5	1.2	1.0	1.1	1.1	1.1	1.4	1.7	4.4	1.0	1.66
Ratio of tubes to machines	1.70	1.14	1.05	1.12	1.02	1.11	1.29	1.36	1.48	1.00	1.22
Number of facilities	146	280	65	1,508	122	134	200	141	740	904	5,263

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.

Table 2. Darkroom procedures from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Facility data	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Darkroom:											
Facilities with no darkroom	2.7	28.2	38.5	16.1	9.0	9.0	8.0	19.2	8.5	16.5	16.0
Darkrooms surveyed that were light-tight	94.7	81.9	92.3	84.0	86.1	89.2	83.7	86.7	89.3	86.4	85.5
Automatic processing used:											
Yes	24.6	.7	.0	.2	3.3	.0	.5	2.8	14.2	.4	3.5
No	56.8	68.6	78.5	85.8	86.9	95.5	92.5	80.1	77.4	79.1	78.9
Undetermined	18.5	30.7	21.5	14.0	9.8	4.5	7.0	17.0	8.4	20.5	17.6
Number of facilities	146	280	65	1,508	122	134	200	141	740	904	5,263

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.

Darkroom procedures. Under the item "light-tightness of darkroom" (table 2), the offices of pediatricians and internists show the highest percent of facilities having no darkroom. This may be due to the high percentage possessing fluoroscopes that are not part of a combination unit having both radiographic and fluoroscopic capabilities. The data indicate that automatic film processing units are most likely to be found in facilities with the largest workloads (radiologists' offices and hospitals).

Equipment type and operating characteristics. Table 3 shows the variations in maximum kilovoltage and maximum milliamperage. The category "unknown" under maximum kilovoltage peak shows several results between 10 and 18 percent. These, and probably most of the unknowns, may conceivably be attributed to older equipment. There are fewer "unknowns" for the maximum milliamperage category. This is not unreasonable since milliamperage is more likely to be known on the same equipment for which kilovoltage is not known.

Filtration. As can be seen in table 4, there was an increase in the percentage of units having 2.5 mm or more aluminum equivalent filtration from the "before survey" to the "after survey" findings. This probably reflects, at least in part, the effects of the Bureau of Radiological Health's program of supplying filters to the States. In reports to come, the data on filtration will be related to the kVp of the machine, to make the evaluation of filtration adequacy more meaningful.

Exposure switch, timer, and protective devices. Gonadal shields for patients do not appear to be in general use (table 5). They are often present in types of facilities and practices where the workload is greatest. These protective devices were present in 65 percent of radiologists' offices and in 33 percent of the offices of general practitioners. Other protective features were generally more widely used.

Procedures and related factors for the major part of the workload. As can be seen in table 6, a high percentage of the examinations for most specialties

Table 3. Equipment type and operation characteristics identification from medical x-ray protection surveys as of June 30, 1967, by type of facility or type of practice

Radiographic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Combination (radiographic-fluoroscopic capability):											
Yes	78.3	80.0	80.6	64.6	11.5	57.8	77.0	68.5	46.9	10.8	46.4
No	20.9	19.5	19.4	33.2	87.7	42.2	23.0	29.1	52.3	88.6	52.5
Unknown	.8	.6	.0	2.2	.8	.0	.0	2.4	.9	.6	1.1
Type of x-ray machine:											
Fixed radiographic	86.0	90.1	96.8	86.4	92.7	84.4	93.1	84.2	57.2	88.5	77.3
Photofluorographic	3.3	.6	.0	.1	.0	.0	1.0	4.2	3.2	.1	1.7
Mobile	4.5	.0	3.2	8.6	4.9	12.5	3.9	4.2	36.8	9.7	17.5
Other and unknown	6.1	9.4	.0	4.9	2.5	3.1	2.0	7.3	2.8	1.7	3.6
Maximum kilovolt peak:											
< 50	.0	.0	.0	.2	.0	.8	.0	.0	.25	.2	.4
50 – 74	.8	1.1	3.2	3.1	1.6	2.3	.0	1.2	2.3	3.5	4.4
75 – 99	4.9	20.6	19.4	17.6	13.1	27.3	10.8	6.7	16.8	33.6	18.9
100 –149	78.3	67.2	58.1	63.2	76.2	60.9	77.4	72.1	59.2	43.2	57.1
150 –249	11.9	.6	3.2	1.3	2.5	1.6	3.9	3.0	8.3	1.0	4.1
≥250	.8	.0	.0	.2	.8	.0	.5	.0	.7	.4	.4
Unknown	3.3	10.6	16.1	14.4	5.7	7.0	7.4	17.0	12.6	18.1	14.7
Maximum milliamperage:											
< 50	5.7	12.8	25.8	20.0	10.7	32.0	9.3	2.4	24.3	27.9	24.1
50 – 99	.0	6.7	9.7	9.3	1.6	9.4	3.4	3.0	3.2	29.2	8.7
100 –199	3.3	40.5	41.9	45.1	28.7	43.7	35.3	21.2	8.1	20.6	22.3
200 –299	31.1	26.1	12.9	13.8	42.6	10.2	28.9	38.2	23.5	4.6	18.4
300 –399	47.5	7.8	.0	4.2	11.5	2.3	17.2	17.6	25.4	.9	13.3
≥400	9.0	1.1	3.2	.4	1.6	.0	1.0	2.4	7.7	.4	3.1
Unknown	3.3	5.0	6.4	7.2	3.3	2.3	4.9	15.2	7.8	16.2	10.0
Number of x-ray machines	244	180	31	1,393	122	128	204	165	1,985	906	6,380

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.

Table 4. Filtration from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Radiographic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Total filtration before survey (mm. of Al. equivalent):											
<1.5	3.3	25.0	38.7	35.6	18.9	41.4	23.0	24.8	17.3	18.6	23.9
1.5 –2.4	14.8	27.2	29.0	27.7	25.4	26.6	26.5	21.2	16.1	23.1	22.2
≥2.5	76.1	37.8	25.8	32.8	54.1	29.0	45.6	47.2	58.5	54.7	47.8
Unknown[b]	5.7	10.0	6.4	3.8	1.6	3.1	4.9	6.7	8.2	3.5	6.2
Total filtration after survey (mm. of Al. equivalent):											
<1.5	2.4	13.3	16.1	14.6	11.5	14.8	9:3	7.9	9.8	4.4	10.4
1.5 –2.4	11.4	17.8	16.1	19.6	16.4	21.1	17.2	11.5	15.0	15.0	16.7
≥2.5	77.8	57.8	61.3	58.5	69.7	60.1	66.2	65.4	66.4	75.8	64.7
Unknown[b]	7.4	11.1	6.4	7.2	2.5	3.9	7.4	15.2	8.8	4.7	8.0
Number of x-ray machines	244	180	31	1,303	122	128	204	165	1,985	906	6,380

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] A large proportion of "unknowns" in this group represents entries not checked off because the filtration was not changed. Please note that "total filtration" after survey showed improving trend.

Table 5. Exposure switch, timer, and protection devices from medical x-ray protection surveys as of June 30, 1967, by type of facility or type of practice

Radiographic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Exposure switch location—adequate	77.9	82.2	96.8	86.1	91.0	85.9	92.2	85.4	83.9	89.3	85.5
Timer—adequate	93.0	96.7	93.6	97.1	96.8	96.8	98.5	97.6	94.4	94.5	95.5
Gonadal shields for patients present	65.2	36.7	32.3	33.4	54.1	22.6	40.7	59.4	48.0	26.9	38.2
Operator protection—adequate	95.9	83.3	83.9	84.6	93.5	77.3	91.7	93.3	90.8	87.5	87.7
Primary and secondary barriers—adequate	92.6	79.4	80.6	84.1	90.2	82.0	89.7	85.4	77.3	89.5	83.4
Diagnostic type tube housing	84.0	81.1	80.6	83.5	90.2	92.9	87.2	80.6	85.2	93.0	86.7
Number of x-ray machines	244	180	31	1,393	122	128	204	165	1,985	906	6,380

The difference between the percentages presented and 100 percent is accounted for by negative or unknown categories.
[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.

were chest examinations. Orthopedists reported about as many extremity procedures as chest examinations. Two-thirds of the chiropractors reported procedures on the spine as their major part of the workload.

Proper beam size is determined on the spot by the surveyors. In the case of rectangular collimation, the surveyor has been instructed to allow no more than 1 inch on each side over and above the film dimensions. Hence, beam size for a 14- by 17-inch film should not exceed 16- by 19-inches. In the case of circular collimation, no more than 1 inch is allowed on each end of a diagonal through the film. This permits a beam diameter of 24 inches when a 14- by 17-inch film is required.

It appears that in a majority of the examinations reported, a circular x-ray beam was used with a 14- by 17-inch film. The beam size associated with 32 percent of such examinations is equal to or greater than 25 inches. Inasmuch as the long diagonal of the 14- by 17-inch film is only 22 inches, none of the facility categories is free of some problem in proper collimation according to film size. For hospitals and for radiologists' offices excessive beam size occurs in 21 and 25 percent of the facilities, respectively. This indicates that in a number of facilities the reduction of improper beam size remains as an area of needed emphasis. There appears also to exist a relationship between proper collimation and the use of a variable collimator. In most instances where the percentage of the machines having variable collimation is low, the percentage showing improper collimation is high (chiropractors are an exception).

Table 6. Procedures and related factors for major part of workload from medical x-ray protection surveys as of June 30, 1967, by type of facility or type of practice

Radiographic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Usual type of examination:											
Chest	76.6	94.4	83.9	82.7	31.2	60.1	91.2	87.3	63.7	8.9	59.0
Extremities	2.4	.0	6.4	8.0	30.3	6.2	3.9	2.4	5.7	2.4	8.5
Spine	2.4	1.1	3.2	.4	17.2	9.4	.5	.0	.9	66.1	10.8
Usual kilovolt peak:											
50–74	49.2	66.1	58.1	67.6	60.7	59.4	69.6	61.8	48.1	50.8	55.3
75–99	36.5	19.4	29.0	14.3	23.0	14.1	19.6	24.2	31.3	31.0	24.1
Usual milliampere-seconds:											
< 6	11.9	11.1	25.8	10.7	12.3	6.2	12.8	6.1	17.4	2.3	11.4
6–25	61.5	76.1	61.3	72.2	50.8	64.1	78.4	77.6	51.9	17.8	53.6
26–75	10.7	4.4	3.2	5.3	12.3	3.9	2.5	5.4	11.6	27.5	11.8
Usual film size (inches):											
14 by 17	81.2	94.4	64.5	80.7	47.5	69.5	92.6	88.5	70.8	42.5	67.0
10 by 12	6.2	1.7	19.4	5.1	16.4	2.3	2.4	2.4	10.0	4.6	7.5
8 by 10	.4	.6	6.4	6.7	25.4	9.4	1.5	1.2	4.0	31.4	10.7
Usual film distance (inches):											
30–39	6.2	1.7	12.9	11.4	35.2	21.9	4.9	6.7	17.4	47.2	19.8
40–49	9.8	5.0	6.4	3.6	27.0	5.5	1.5	4.2	16.6	20.2	11.1
70–79	73.4	87.2	67.7	75.2	30.3	54.7	83.3	83.6	47.1	7.7	50.1
Usual beam type:											
Circular	50.0	67.2	87.1	74.2	61.5	66.4	58.8	64.2	47.6	66.6	59.7
Rectangular	32.8	22.8	6.4	10.3	22.1	12.5	25.5	21.2	29.9	14.6	20.0
Square	3.7	3.3	.0	3.4	4.1	2.3	3.4	1.8	6.7	3.1	4.2
Usual beam size (inches):											
<20	34.4	10.6	16.1	13.7	46.7	17.2	22.6	17.0	37.1	30.4	27.5
20–24	23.0	12.8	12.8	14.9	19.7	17.9	12.7	17.0	21.1	19.3	17.7
≥25	25.4	66.1	61.3	53.9	14.0	39.8	48.0	53.3	20.8	20.3	32.0
Collimation:											
Proper	30.7	17.8	19.4	22.6	36.9	28.1	23.0	18.8	27.7	48.1	30.2
Improper	17.6	66.7	64.5	53.1	22.9	44.6	45.1	46.1	20.7	22.5	32.8
Variable	43.0	8.3	6.4	7.8	28.7	7.8	17.6	19.4	34.7	8.0	18.8
Permanent	.0	.0	.0	.7	.0	.0	.0	.0	.2	2.9	1.1
Number of x-ray machines	244	180	31	1,393	122	128	204	165	1,985	906	6,380

The difference between the percentages presented and 100 percent is accounted for by infrequently reported items of information and negative or unknown categories.

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.

Fluoroscopic equipment characteristics (table 7). Over 50 percent of the x-ray machines in the possession of internists have fluoroscopic capability only, and more than 60 percent of the x-ray machines with fluoroscopic capability are of the vertical type. It may be noted that nearly one-half of all x-ray machines with fluoroscopic capability are in hospitals or in radiologists' offices. Only 15 percent of these facilities possess image intensifying devices, the other facilities fare more poorly in this capability for reducing patient exposure.

Fluoroscopic screens. As shown in table 8, fluoroscopic screens are not interlocked with x-ray tube in approximately 15 to 25 percent of the facilities of pediatricians, osteopaths, and chiropractors; in such situations the operator may be subjected to excessive exposure. There is no immediate explanation for the high percentage in the "undetermined" category for leaded screens among general practitioners in private offices and clinics.

The findings of a fairly high percentage of cases (40 percent) in which the useful beam is not limited to the fluoroscopic screen, as compared to the low percentage of cases (8 percent) of improperly functioning shutters, may be explained in part by the failure of the surveyor to evaluate shutter function and beam limitation at the maximum screen-to-target distance.

Target-to-panel distance, roentgen output at the panel surface, lighttightness of fluoroscopic room (table 9). In most instances, target-to-panel distances comply with the recommendations in NBS Handbook 76 (*2*) and NCRP Report No. 33 (*3*).

Table 7. Equipment identification from medical x-ray protection surveys as of June 30, 1967, by type of facility or type of practice

Fluoroscopic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Combination (radiographic-fluoroscopic capability):											
Yes	98.3	42.5	19.5	69.8	--------	85.3	92.1	92.2	95.4	85.0	79.4
No	1.1	56.5	80.5	27.4	--------	11.8	5.9	6.5	4.1	10.0	19.3
Unknown	.6	.9	.0	2.8	--------	2.9	2.0	1.3	.5	5.0	1.2
Type:											
Vertical	.0	64.0	9.8	31.5	--------	23.5	6.9	7.8	2.5	25.0	19.3
Horizontal	3.9	3.3	70.7	7.2	--------	20.6	5.9	2.6	3.7	20.0	6.7
Tilting table	96.1	30.8	19.5	55.3	--------	50.0	83.2	80.5	91.9	50.0	70.9
Unknown	.0	1.9	.0	6.0	--------	5.9	4.0	9.1	1.9	5.0	3.1
Image intensifying device used:											
Yes	16.0	1.9	.0	1.3	--------	5.9	4.0	5.2	14.1	.0	7.9
No	81.2	95.8	97.6	91.3	--------	82.3	90.1	83.1	82.6	95.0	87.0
Unknown	2.8	2.3	2.4	7.4	--------	11.8	5.9	11.7	3.3	5.0	5.1
Number of x-ray machines	181	214	41	470	[b] 5	34	101	77	845	20	2,266

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

Table 8. Fluoroscopic screens from medical x-ray protection surveys from 25 States and 2 territories as of June 30, 1967, by type of facility or type of practice

Fluoroscopic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Fluoroscopic screen ganged to x-ray tube:											
Yes	98.3	93.5	73.2	86.2	--------	76.5	87.1	93.5	96.9	75.0	91.8
No	.0	3.3	14.6	3.8	--------	14.7	.0	2.6	.7	15.0	3.0
Unknown	1.7	3.3	12.2	10.0	--------	8.8	12.9	3.9	2.4	10.0	5.1
Shutter functioning:											
Properly	94.5	86.0	78.0	76.8	--------	61.8	77.2	87.0	91.1	75.0	85.6
Improperly	3.9	9.8	12.2	11.1	--------	17.6	6.9	9.1	5.0	5.0	7.5
Fixed	.0	.5	4.9	.4	--------	5.9	.0	.0	.6	10.0	.8
Undetermined	1.7	3.7	4.9	11.7	--------	14.7	15.8	3.9	3.3	10.0	6.1
Useful beam limited to screen:											
Yes	68.5	38.3	46.3	32.1	--------	35.3	52.5	59.7	69.8	40.0	52.3
No	28.2	55.6	46.3	53.8	--------	41.2	30.7	35.1	26.1	50.0	40.2
Unknown	3.3	6.1	7.3	14.0	--------	23.5	16.8	5.2	4.0	10.0	7.5
Leaded screen (from revised form only):											
Satisfactory	87.9	91.0	--------	73.5	--------	--------	46.2	--------	86.1	--------	81.8
Not satisfactory	3.0	4.4	--------	.8	--------	--------	.0	--------	2.5	--------	2.0
Not applicable	1.5	.0	--------	2.5	--------	--------	3.8	--------	2.9	--------	2.6
Undetermined	7.6	4.4	--------	23.1	--------	--------	50.0	--------	8.4	--------	13.6
Number of x-ray machines	181	214	41	470	[b] 5	34	101	77	845	20	2,266
Number of fluoroscopic cards (revised form)	66	45	[b] 1	121	[b] 2	[b] 3	26	[b] 5	238	[b] 2	544

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

In at least 86 percent of the cases the target-to-panel distance was at least 12 inches. Operation at a distance of less than 12-inches distance was observed in about 8 to 9 percent of pediatrician, private offices of general practitioners, and osteopath facilities. This may account in part for the relatively high percentage of outputs in excess of 10 roentgens per minute at the panel surface for these specialties. The high percentage of facilities reporting less than 10 roentgens per minute is note-

Table 9. Distance, roentgen output and fluoroscopic room from medical x-ray protection surveys of June 30, 1967, by type of facility or type of practice

Fluoroscopic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Target-to-panel distance (inches):											
<12	.0	7.5	2.4	8.5	....	8.8	2.0	.0	0.6	.0	3.8
12–14	5.5	46.3	48.8	28.3	....	17.6	8.9	14.3	5.7	20.0	19.4
15–17	22.1	19.6	24.4	27.9	....	23.5	22.8	24.7	15.4	25.0	20.5
18–20	63.0	17.8	12.2	17.9	....	32.4	41.6	46.8	69.1	10.0	39.2
≥21	2.8	.9	2.4	2.6	....	.0	3.0	1.3	3.4	15.0	2.7
Unknown	6.6	7.9	9.8	14.9	....	17.6	21.8	13.0	5.8	30.0	9.9
Percent in compliance with Handbook 76 (*2*)	93.4	84.6	87.8	76.6	....	73.6	76.2	87.0	93.6	70.0	86.3
Roentgen output at panel surface (R/min):											
< 1.0	1.1	.9	.0	1.3	....	.0	.0	1.3	2.2	.0	1.5
1.0– 9.9	89.5	59.4	58.5	60.0	....	32.4	72.3	79.2	84.1	45.0	71.8
10.0–14.9	5.5	15.4	17.1	7.7	....	14.7	4.0	10.4	4.1	5.0	7.4
15.0–19.9	.0	6.5	7.3	4.5	....	5.9	.0	2.6	1.4	10.0	3.2
≥20.0	1.2	10.3	14.7	8.2	....	8.8	3.0	1.3	1.2	5.0	4.8
Unknown	2.8	7.5	2.4	18.3	....	38.2	20.8	5.2	6.9	35.0	11.4
Percent in compliance with Handbook 76 (*2*)	90.6	60.3	58.5	61.3	....	32.4	72.3	80.5	86.3	45.0	73.3
Lighttightness of fluoroscopic room:											
Lighttight	75.1	65.9	53.7	55.7	....	52.9	64.4	70.1	69.6	30.0	64.5
Not lighttight	12.7	23.8	26.8	23.4	....	29.4	12.9	15.6	19.0	55.0	20.1
Not applicable	2.2	.5	.0	.2	....	.0	.0	.0	2.6	.0	1.3
Unknown	9.9	9.8	19.5	20.6	....	17.6	22.8	14.3	8.8	15.0	14.1
Number of x-ray machines	181	214	41	470	[b] 5	34	101	77	845	20	2,266

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

worthy, and suggests that the 10 roentgens per minute limit specified in NBS Handbook 76 can be reduced.[3] It is of interest that the types of facility that reported less than 1 roentgen per minute are the same types that reported using image intensifying devices. NCRP Report No. 33 (*3*) prescribes the expression of output at the panel surface in terms of roentgens per milliampere-minute; future reports on surveys will attempt to comply with this recommendation.

With regard to lighttightness of the fluoroscopic room, the types of facilities that reported the item as "not applicable" were the same as those reporting the use of image intensifying devices.

Fluoroscopic filtration. This parameter is difficult to measure in the type of survey conducted, since it would in most instances, necessitate the partial dismantling of the fluoroscopic table. This accounts for the high percentage of "unknown" shown in table 10, and suggests a need for the training of survey personnel in methods of determining filtration of fluoroscopes by indirect means such as half-value-layer determinations.

Time information. The percentage of facilities reporting fluoroscopes that are not equipped with manually reset cumulative timers is of particular interest. As indicated in table 11, this percentage is high where one might expect to find older equipment; this might even serve to indicate the general age of equipment. A timer can be an expensive addition to old equipment, and many owners might be reluctant to add this feature voluntarily without a vigorous program in the State.

Dark adaptation. The data in table 12 show that pediatricians and osteopaths, in particular, are likely to dark adapt for a shorter time period than the average for the sample. One might speculate that this could be associated with increased patient exposure, if dark adaptation is insufficient and the milliamperage is set higher than would be necessary with proper dark adaptation practices.

[3] The State of New Jersey Radiation Protection Code, Chapter 2, Section 18.2.11 (January 1965) restricts the output at the panel surface to 5 roentgens per minute or less and has had no difficulty in obtaining compliance.

Table 10. Filtration from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Total filtration before survey (mm. of Al. equivalent):											
<1.5	2.3	16.4	29.2	24.7	--------	23.5	7.0	13.0	4.4	15.0	12.4
1.5 -2.4	2.8	14.5	24.4	14.4	--------	23.5	10.9	5.2	3.3	20.0	9.4
≥2.5	52.5	36.4	19.5	33.2	--------	38.3	43.6	46.8	49.9	40.0	42.7
Unknown[b]	42.5	32.7	26.8	27.7	--------	14.7	38.6	35.1	42.4	25.0	35.5
Percent in compliance with Handbook 76 (2)	52.5	36.4	19.5	33.2	--------	38.3	43.6	46.8	49.9	40.0	42.7
Total filtration after survey (mm. of Al. equivalent):											
<1.5	.6	12.2	12.2	13.9	--------	14.7	3.0	7.8	2.7	5.0	7.2
1.5 -2.4	2.8	12.2	17.1	10.7	--------	23.6	11.8	.0	2.8	20.0	7.6
≥2.5	51.9	41.1	41.5	45.5	--------	41.2	45.6	49.4	51.1	45.0	47.8
Unknown[b]	44.8	34.6	29.3	30.0	--------	20.6	39.6	42.9	43.3	30.0	37.6
Percent in compliance with Handbook 76 (2)	51.9	41.1	41.5	45.5	--------	41.2	45.6	49.4	51.1	45.0	47.8
Number of x-ray machines	181	214	41	470	[c] 5	34	101	77	845	20	2,266

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] A large proportion of "unknowns" in the group represents entries not checked off because the filtration was not changed from the previous conditions. Please note that "total filtration" after survey showed improving trend.
[c] Sample size too small to provide meaningful data.

Table 11. Timer information from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Deadman type of exposure switch:											
Yes	97.8	94.4	95.1	88.3	--------	85.3	86.1	96.1	97.2	90.0	93.8
No	.6	2.3	.0	1.5	--------	2.9	1.0	.0	.6	.0	1.2
Unknown	1.7	3.3	4.9	10.2	--------	11.8	12.9	3.9	2.1	10.0	5.0
Manually reset cumulative timer:											
Yes	58.0	21.0	12.2	18.1	--------	17.6	25.7	40.3	56.4	5.0	38.0
No	39.8	77.6	85.4	73.6	--------	73.5	57.4	55.8	41.4	85.0	57.5
Unknown	2.2	1.4	2.4	8.3	--------	8.8	16.8	3.9	2.1	10.0	4.5
Cumulative timer terminates exposure:											
Yes	56.9	20.1	12.2	16.4	--------	20.6	22.8	40.3	56.1	5.0	37.2
No	40.3	77.1	82.9	74.5	--------	70.6	58.4	55.8	41.6	85.0	57.7
Unknown	2.8	2.8	4.9	9.2	--------	8.8	18.8	3.9	2.2	10.0	5.0
Number of x-ray machines	181	214	41	470	[b] 5	34	101	77	845	20	2,266

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

Accessory shielding. The absence of Bucky-slot covers and leaded drapes around the screen seems to correlate with types of facility having older equipment. The data in table 13 tend to support the premise that in facilities where the equipment is likely to be new or of recent vintage, these accessories are more likely to be present than in facilities with older equipment.

Upper gastrointestinal examinations. It is evident from the data in table 14 that the heaviest load of upper gastrointestinal examinations occurs in radiologists' offices and in hospitals. The high percentage in the "unknown" category reported for internist and general practitioners may well be due to the infrequency of the procedure in these specialties, and that the coding for "un-

Table 12. Dark adaptation from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Number of minutes of dark adaptation:											
< 5	7.7	7.5	14.6	16.6	--------	20.6	8.9	1.3	8.3	25.0	10.3
5 – 9	3.3	16.4	43.9	10.4	--------	11.8	3.0	10.4	3.6	20.0	8.1
10 –14	13.8	22.0	14.6	17.2	--------	20.6	12.9	13.0	12.4	5.0	15.6
15 –19	32.0	19.6	2.4	13.6	--------	8.8	13.9	32.5	25.3	5.0	20.8
≥20	32.6	15.0	.0	16.2	--------	11.8	34.6	22.1	40.2	15.0	27.2
Unknown	10.5	19.6	24.4	26.0	--------	26.5	26.7	20.8	10.2	30.0	18.0
Average minutes per user	17.5	13.7	7.3	12.8	--------	11.1	17.7	16.8	18.1	10.1	15.8
Number of x-ray machines	181	214	41	470	[b] 5	34	101	77	845	20	2,266

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

known" rather than "not performed" was used. The duration of tube activation per examination does not vary too greatly from the average of 3.1 minutes.

Lower gastrointestinal examination. The data in table 15 indicate that lower gastrointestinal examinations are also performed chiefly in radiologists' offices and in hospitals. Also, the coding for "unknown" is considered to be subject to the same error as for the upper tract examinations. The duration of tube activation per examination averaged 2.9 minutes.

Spot films and fluoroscopic examinations other than gastrointestinal. As can be seen (table 16), all other fluoroscopic examinations combined do not equal the number involving the gastrointestinal region. The distribution by number of spot films which may be a part of any fluoroscopic examination is roughly consistent with the fluoroscopic patient workload. This is particularly evident in the rate of spot films taken in radiologists' offices, hospitals, and multiple specialty clinics.

Table 13. Accessory shielding from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Leaded gloves:							[a]				
Yes	97.8	90.2	95.1	83.4	--------	70.6	85.2	94.8	98.4	70.0	92.2
No	1.7	7.9	4.9	11.3	--------	20.6	3.0	2.6	1.0	20.0	5.2
Unknown	.6	1.9	.0	5.3	--------	8.8	11.9	2.6	.6	10.0	2.6
Leaded apron:											
Yes	98.3	91.6	82.9	83.8	--------	76.5	85.2	92.2	98.3	70.0	91.9
No	1.1	7.0	17.1	12.1	--------	14.7	3.0	6.5	1.1	20.0	5.8
Unknown	.0	1.4	.0	4.0	--------	8.8	11.9	1.3	.6	10.0	2.2
Bucky slot cover:											
Yes	52.5	12.1	2.4	9.8	--------	8.8	29.7	18.2	58.4	10.0	34.0
No	45.9	40.2	48.8	62.8	--------	73.5	52.5	74.0	37.9	65.0	48.6
Not applicable	.0	45.3	48.8	22.3	--------	11.8	5.0	5.2	2.5	15.0	14.4
Unknown	1.7	2.3	.0	5.1	--------	5.9	12.9	2.6	1.2	10.0	3.0
Leaded drapes around screen:											
Yes	39.2	6.1	2.4	6.4	--------	8.8	16.8	15.6	35.1	10.0	21.3
No	60.2	63.1	56.1	78.1	--------	79.4	71.3	79.2	60.3	80.0	67.1
Not applicable	.0	28.5	41.5	11.3	--------	5.9	.0	2.6	2.4	.0	7.9
Unknown	.6	2.3	.0	4.3	--------	5.9	11.9	2.6	2.1	10.0	3.6
Number of x-ray machines	181	214	41	470	[b] 5	34	101	77	845	20	2,266

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

Table 14. Upper gastrointestinal examination from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information (revised form)	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Kilovolt peak:											
Not performed	.0	26.6	....	26.4	....	....	3.8	....	2.5	....	12.3
< 50	.0	.0	....	.8	....	....	.0	....	.0	....	.2
50–74	10.6	11.1	....	14.9	....	....	7.7	....	6.7	....	9.4
75–99	66.7	22.2	....	15.7	....	....	23.1	....	57.5	....	42.6
100–149	6.1	.0	....	.8	....	....	.0	....	8.8	....	4.8
≥150	.0	2.2	....	.0	....	....	.0	....	.8	....	.6
Unknown	16.7	37.7	....	41.3	....	....	65.4	....	23.5	....	30.1
Minutes tube activated per exam:											
Not performed	.0	26.6	....	26.4	....	....	3.8	....	2.5	....	12.3
1	6.1	11.1	....	12.4	....	....	.0	....	2.1	....	6.1
2	22.7	17.8	....	4.1	....	....	11.5	....	19.7	....	15.1
3	18.2	4.4	....	8.3	....	....	19.2	....	26.0	....	17.1
4	12.1	2.2	....	3.3	....	....	.0	....	10.1	....	7.7
5	22.7	2.2	....	3.3	....	....	3.8	....	11.8	....	9.4
> 6	1.5	.0	....	.0	....	....	.0	....	1.7	....	1.1
Unknown	16.7	35.5	....	42.1	....	....	61.5	....	26.0	....	31.2
Average number of minutes	3.3	2.1	....	2.4	....	....	2.9	....	3.2	....	3.1
Number of examinations per week:											
Not performed	....	26.6	....	29.8	....	....	7.7	....	3.4	....	12.3
< 5	12.1	28.9	....	24.8	....	....	34.6	....	26.0	....	23.5
5–9	24.2	6.7	....	1.6	....	....	.0	....	13.0	....	10.3
10–14	22.7	.0	....	1.6	....	....	.0	....	10.9	....	8.4
15–19	9.1	.0	....	.0	....	....	.0	....	6.7	....	4.4
20–29	10.6	.0	....	.8	....	....	.0	....	8.4	....	5.3
≥30	4.5	2.2	....	.8	....	....	.0	....	6.7	....	4.3
Unknown	16.7	35.5	....	40.5	....	....	57.7	....	24.8	....	31.4
Average number of exams	12.5	5.2	....	5.1	....	....	2.0	....	13.0	....	11.5
Number of x-ray machines	66	45	[b] 1	121	[b] 2	[b] 3	26	[b] 5	238	[b] 2	544

[a] All facilities includes information from 35 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

Table 15. Lower gastrointestinal examination from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information (revised form)	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Kilovolt peak:											
Not performed	1.5	31.1	....	32.2	....	....	3.8	....	3.8	....	15.3
< 50	.0	.0	....	.0	....	....	.0	....	.0	....	.0
50–74	12.1	6.7	....	10.7	....	....	7.7	....	7.1	....	8.3
75–99	65.2	13.3	....	8.3	....	....	23.1	....	56.3	....	38.6
100–149	3.0	.0	....	.0	....	....	.0	....	8.4	....	4.0
≥150	.0	.0	....	.0	....	....	.0	....	.0	....	.0
Unknown	18.2	48.8	....	48.8	....	....	65.4	....	24.4	....	33.8
Minutes tube activated per examination:											
Not performed	1.5	31.1	....	32.2	....	....	3.8	....	3.8	....	15.3
1	9.1	4.4	....	4.1	....	....	.0	....	5.5	....	5.2
2	31.8	11.1	....	3.3	....	....	11.5	....	21.4	....	16.2
3	21.2	2.2	....	5.8	....	....	19.2	....	25.2	....	16.4
4	6.1	2.2	....	3.3	....	....	.0	....	8.8	....	6.4
5	12.1	.0	....	2.5	....	....	3.8	....	8.0	....	5.7
≥6	.0	.0	....	.0	....	....	.0	....	1.2	....	.6
Unknown	18.2	48.8	....	48.8	....	....	61.5	....	26.0	....	34.4
Average number of minutes	2.8	2.1	....	2.8	....	....	2.9	....	3.0	....	2.9
Number of examinations per week:											
Not performed	1.5	31.1	....	33.9	....	....	7.7	....	4.2	....	15.3
< 5	28.8	13.3	....	14.9	....	....	34.6	....	31.5	....	24.3
5–9	30.3	2.2	....	1.6	....	....	.0	....	12.2	....	9.9
10–14	7.6	4.4	....	.8	....	....	.0	....	11.3	....	7.0
15–19	12.1	.0	....	.0	....	....	.0	....	5.9	....	4.2
20–29	3.0	.0	....	.8	....	....	.0	....	6.7	....	3.7
≥30	.0	.0	....	.0	....	....	.0	....	2.9	....	1.5
Unknown	16.7	48.8	....	47.9	....	....	57.7	....	25.2	....	34.2
Average number of examinations	7.8	4.8	....	4.3	....	....	2.0	....	9.5	....	8.4
Number of x-ray machines	66	45	[b] 1	121	[b] 2	[b] 3	26	[b] 5	238	[b] 2	544

[a] All facilities includes information from 35 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

Table 16. Other examinations and spot films from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information (revised form)	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Number of other examinations per week:											
None	20.4	14.0	7.3	15.1	--------	8.8	10.9	6.5	23.0	10.0	16.6
<10	16.6	21.9	.0	27.2	--------	11.8	16.9	19.5	19.7	25.0	21.5
10–19	5.0	6.0	.0	2.3	--------	.0	1.0	1.3	6.5	.0	4.7
20–39	4.4	4.6	.0	1.0	--------	.0	.0	6.5	3.4	.0	3.0
≥40	.6	.0	.0	.8	--------	.0	.0	1.3	1.2	.0	.9
Unknown	53.0	53.0	92.7	53.4	--------	79.4	71.3	64.9	46.1	65.0	53.4
Average number per week	11.0	9.0	2.0	6.1	--------	2.5	3.9	11.8	10.6	2.0	9.0
Number of spot films per week:											
None	6.6	69.2	63.4	57.0	--------	50.0	24.8	26.0	17.7	75.0	37.4
< 10	5.5	6.1	4.9	9.6	--------	.0	17.8	5.2	11.0	5.0	8.7
10– 24	9.9	4.6	.0	3.6	--------	5.9	9.9	13.0	11.6	.0	7.9
25– 49	14.9	.9	.0	.4	--------	2.9	9.9	18.2	12.5	.0	7.6
50– 99	18.3	.4	.0	1.9	--------	.0	4.0	11.7	15.0	.0	8.5
100–199	22.1	.9	.0	.6	--------	.0	3.0	5.2	11.6	.0	6.7
≥200	10.0	.0	.0	.0	--------	.0	1.0	2.6	5.6	.0	3.2
Unknown	12.7	17.8	31.7	26.8	--------	41.2	29.7	18.2	14.9	20.0	20.0
Average number per week	111.2	22.5	5.0	21.9	--------	20.3	36.1	63.9	81.1	5.0	75.7
Number of x-ray machines	181	214	41	470	[b] 5	34	101	77	845	20	2,266

[a] All facilities includes information from 1,023 facilities that cannot be classified specifically in any of the above categories.
[b] Sample size too small to provide meaningful data.

Table 17. Total milliampere-minute workload from medical x-ray protection surveys as of June 30, 1967 by type of facility or type of practice

Fluoroscopic card information (revised form)	Type of facility or type of practice (percent)										
	Radiologists	Internists	Pediatricians	General practitioners in private offices	Orthopedists	Osteopaths	General practitioners in clinics	Multiple specialty clinics	Hospitals	Chiropractors	All facilities[a]
Total mA–min/week:											
Not performed	1.5	8.9	--------	18.2	--------	--------	7.7	--------	6.7	--------	8.8
< 50	21.2	55.5	--------	44.6	--------	--------	26.9	--------	26.5	--------	33.3
50– 99	13.6	4.4	--------	5.0	--------	--------	7.7	--------	12.6	--------	9.6
100–149	6.1	8.9	--------	.0	--------	--------	.0	--------	10.5	--------	6.8
150–249	18.2	.0	--------	.8	--------	--------	.0	--------	12.2	--------	8.6
250–499	18.2	.0	--------	.0	--------	--------	.0	--------	12.6	--------	8.1
≥500	1.5	.0	--------	.0	--------	--------	.0	--------	8.0	--------	3.9
Unknown	19.7	22.2	--------	31.4	--------	--------	57.7	--------	10.9	--------	21.0
Average mA–min/week	174.0	41.1	--------	32.7	--------	--------	36.1	--------	197.1	--------	144.4
Number of x-ray machines	66	45	[b] 1	121	[b] 2	[b] 3	26	[b] 5	238	[b] 2	544

[a] All facilities includes information from 35 facilities that cannot be classified in any of the above categories.
[b] Sample size too small to provide meaningful data.

Total milliampere-minutes workload. As would be expected, the greatest part of the fluoroscopic workload is handled in radiologists' offices and in hospitals (table 17).

It should be noted that in tables 14, 15, and 17, there are fewer machines reported than in the other fluoroscopic tables. This change in total numbers is also indicated within table 8. This should be taken into account in relating absolute numbers recorded for the specialties according to procedure and equipment.

Conclusions and recommendations.

The following areas in which major efforts should be made are suggested:

Equipment. The high percentage of facilities having improper collimation, inadequate filtration, lack of accessory shielding, and absence of manually reset cumulative timers on fluoroscopes, indicate that a major effort in the correction of equipment is still needed. This effort, if applied, would help in the reduction of unnecessary population and occupational exposure.

Standardization of survey techniques and data collection. The high percentage of "unknowns" in the data reported emphasize the need for the standardization of surveying techniques and for uniformity and comparability of data collected in State radiological health programs. Survey forms should also be revised using NCRP Report No. 33 as a guide, and all data inquiries should be eliminated that are of doubtful value in defining or assessing radiological health problems and progress.

Technique and judgment. A continuing effort aimed at improving the technique of the operator of the machine and the professional judgment of the physician requesting the examination is essential if the efforts toward dose reduction are to be successful. The use of fluoroscopy in cases where a radiograph would serve a more useful purpose, and inadequate beam collimation in facilities where adequate collimating devices are available, reinforce this conclusion.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, February 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long term concentration trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN), sponsored by the Bureau of Radiological Health and the Bureau of Community Environmental Management, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments have also initiated local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostron-

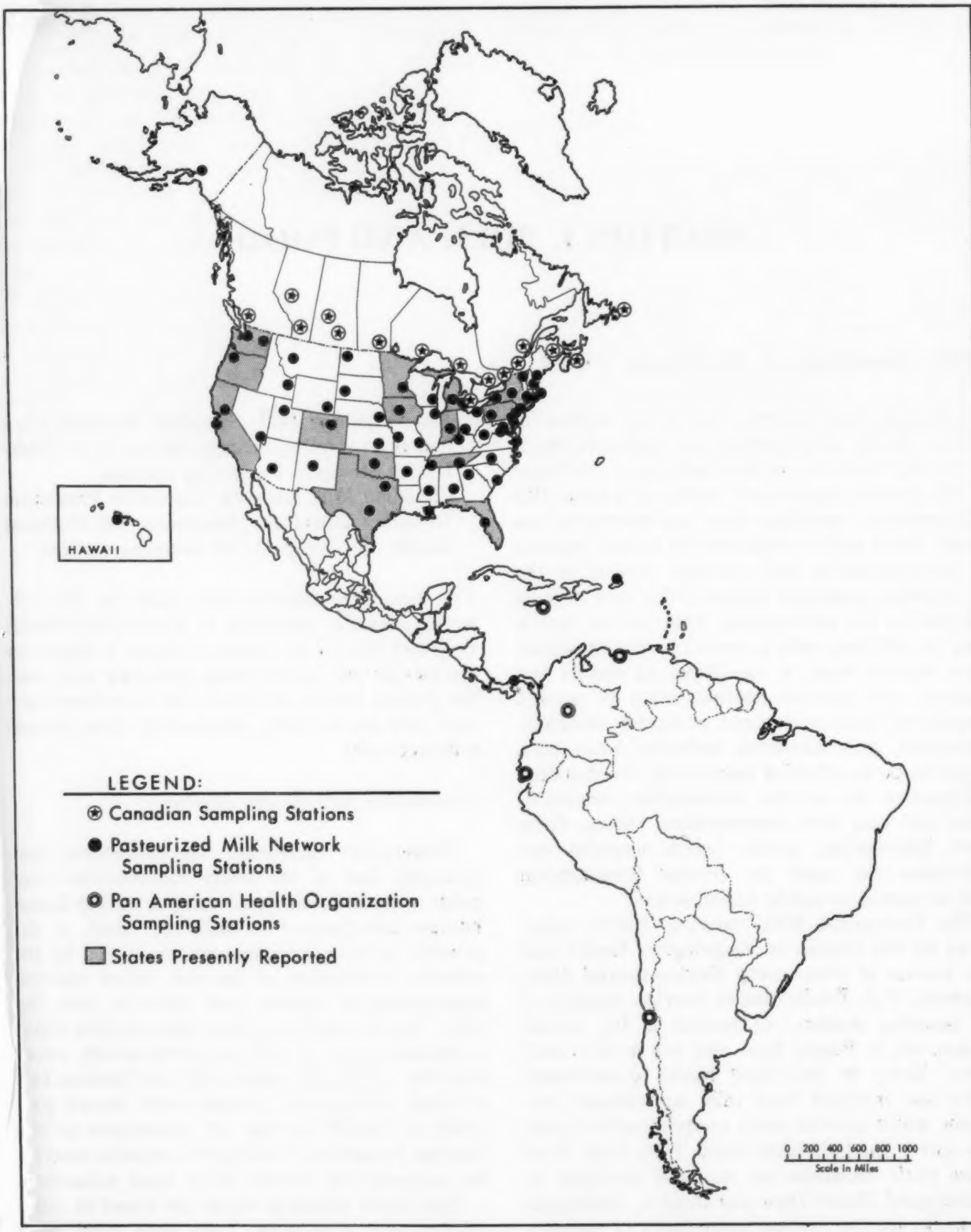

Figure 1. Milk sampling networks in the Western Hemisphere

tium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined in the literature (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium-90, iodine-131, and cesium-137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 of these laboratories participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3- standard deviation limits considered appropriate for the various analyses. Several results were outside the 3-standard deviation limits and the most deviant of these represented biases from the expected values of 20 to 30 percent (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium–137 are relatively constant over short time periods and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine–131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation will also reflect whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration

of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision 2-standard deviations
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance for the use of Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/yr)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	[c]1.5	0.5	[d]2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	[c].5	.17				
Strontium-90	Bone	[c]1.5	.5	[d]200	0–20	20–200	200–2,000
	Bone marrow	[c].5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.
[b] Based on an average intake of 1 liter of milk per day.
[c] A dose of 1.5 rad/yr to the bone is estimated to result in a dose of 0.5 rad/yr to the bone marrow.
[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.
[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1- or 2- year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentra-

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89 Strontium-90 Cesium-137	Bone marrow Bone marrow Whole body	10 in first year total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c]1,110,000 [c]51,000 [c]720,000
Iodine-131	Thyroid	30	10	[d]70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.
[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.
[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.
[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered.

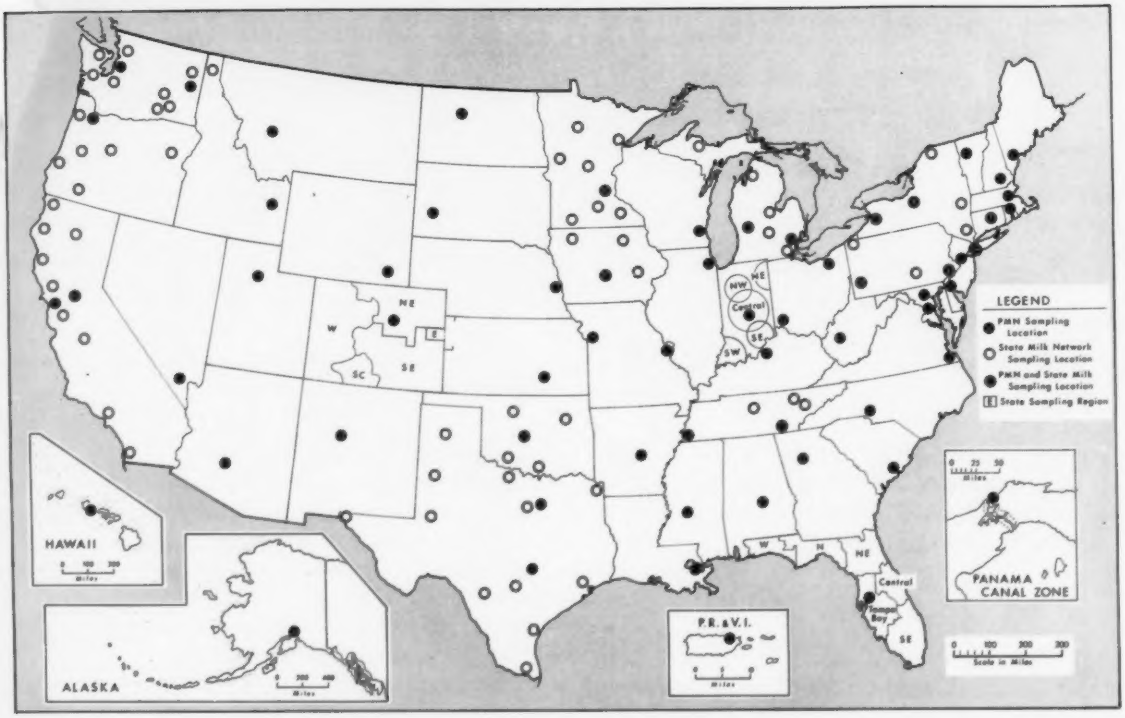

Figure 2. State and PMN milk sampling locations in the United States

tion from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports.* (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-month average, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137, for February 1969 and the 12-month period, March 1968 to February 1969. Except where noted

Table 3. Concentration of radionuclides in milk for February 1969 and 12-month period, March 1968 through February 1969

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	10	8	0(4)	0	8(4)	14
Alaska:	Palmer[c]	P	7	6	0(3)	0	10(3)	13
Ariz:	Phoenix[c]	P	3	1	0(4)	0	0(4)	2
Ark:	Little Rock[c]	P	18	20	0(4)	0	21(4)	19
Calif:	Sacramento[c]	P	0	2	0(3)	0	0(3)	4
	San Francisco[c]	P	4	2	0(4)	0	0(4)	3
	Del Norte	P	10	19	0	0	20	21
	Fresno	P	0	1	0	0	0	3
	Humboldt	P	0	4	0	0	13	12
	Los Angeles	P	0	1	0	0	0	5
	Mendocino	P	0	2	0	0	0	4
	Sacramento	P	0	2	0	0	0	4
	San Diego	P	0	0	0	0	0	3
	Santa Clara	P	0	0	0	0	0	6
	Shasta	P	0	3	0	0	11	4
	Sonoma	P	0	1	0	0	0	4
Colo:	Denver[c]	P	5	5	0(4)	0	0(4)	5
	West	R	(d)		(e)	(e)	(e)	(e)
	Northeast	R	(d)		(e) (3)	1	(e)	(e)
	East	R	(d)		NS	(e)	NS	
	Southeast	R	(d)		NS		NS	
	South Central	R	(d)		NS		NS	
Conn:	Hartford[c]	P	7	9	0(4)	0	13(4)	12
	Central	P	7	8	0(4)	0	4(4)	9
Del:	Wilmington[c]	P	10	10	0(4)	0	15(4)	9
D.C:	Washington[c]	P	9	9	0(3)	0	4(3)	6
Fla:	Tampa[c]	P	8	8	0(4)	0	49(4)	65
	West	R	16	12	0	3	27	23
	North	R	10	14	0	0	31	30
	Northeast	R	11	9	0	2	34	80
	Central	R	10	9	0	2	108	83
	Tampa Bay area	R	8	8	0	0	55	72
	Southeast	R	9	9	0	0	84	114
Ga:	Atlanta[c]	P	11	14	0(4)	0	22(4)	20
Hawaii:	Honolulu[c]	P	5	4	0(4)	0	0(4)	2
Idaho:	Idaho Falls[c]	P	6	6	0(4)	0	10(4)	9
Ill:	Chicago[c]	P	7	9	0(4)	0	9(4)	10
Ind:	Indianapolis[c]	P	8	8	0(4)	0	10(4)	6
	Northeast	P	6	12	0	0	10	12
	Southeast	P	6	10	0	0	20	13
	Central	P	5	9	0	0	10	10
	Southwest	P	4	9	0	0	10	12
	Northwest	P	6	9	0	0	10	12
Iowa:	Des Moines[c]	P	4	6	0(4)	0	10	5
	Iowa City	P	5	7	0(2)	0	8(2)	6
	Des Moines	P	3	6	0(4)	0	8(4)	4
	Spencer	P	4	6	0	0	0	4
	Charles City	P	NS		NS		NS	
Kans:	Wichita[c]	P	4	8	0(4)	0	NS	4
Ky:	Louisville[c]	P	10	12	0(4)	0	0(4)	7
La:	New Orleans[c]	P	16	20	0(4)	0	3(4)	23
Maine:	Portland[c]	P	11	12	0(4)	1	24(4)	28
Md:	Baltimore[c]	P	7	10	0(4)	0	21(4)	8
Mass:	Boston[c]	P	9	12	0(4)	0	6(4)	24
Mich:	Detroit[c]	P	9	9	0(4)	0	21(4)	11
	Grand Rapids[c]	P	10	10	0(4)	0	13(4)	15
	Bay City	P	NA	5	NA	0	NA	8
	Charlevoix	P	7	5	(e) (4)	(e)	16(4)	10
	Detroit	P	6	5	(e) (4)	(e)	7(4)	8
	Grand Rapids	P	7	4	(e) (4)	(e)	14(4)	8
	Lansing	P	NA	4	(e) (2)	(e)	0(2)	3
	Marquette	P	12	8	(e) (2)	(e)	25(2)	26
	Monroe	P	2	3	(e) (2)	(e)	7	1
	South Haven	P	7	4	(e) (3)	(e)	9(3)	5
Minn:	Minneapolis[c]	P	12	12	0(4)	0	18(4)	14
	Bemidji	P	12	16	0	0	21	25
	Mankato	P	4	6	0	0	10	0
	Rochester	P	8	9	0	0	0	0
	Duluth	P	18	20	0	0	26	31
	Worthington	P	6	6	0	0	14	0
	Minneapolis	P	10	12	0	0	16	15
	Fergus Falls	P	8	10	0	0	12	11
	Little Falls	P	10	10	0	0	17	17
Miss:	Jackson[c]	P	13	17	0(4)	0	15(4)	16
Mo.:	Kansas City[c]	P	5	7	0(4)	0	0(4)	4
	St. Louis[c]	P	8	9	0(4)	0	0(4)	5
Mont:	Helena[c]	P	3	4	0(4)	0	5(4)	8
Nebr:	Omaha[c]	P	5	7	0(4)	0	0(4)	5
Nev:	Las Vegas[c]	P	0	1	0(4)	0	0(4)	3
N.H:	Manchester[c]	P	8	13	0(4)	0	22(4)	34
N.J:	Trenton[c]	P	7	10	0(4)	0	7(4)	10
N. Mex:	Albuquerque[c]	P	0	3	0(4)	0	0(4)	2

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for February 1969 and 12-month period, March 1968 through February 1969—Continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES—Continued								
N.Y:	Buffalo[c]	P	7	8	0(4)	0	15(4)	10
	New York City[c]	P	7	12	0(3)	0	11(3)	16
	Syracuse[c]	P	7	9	0(4)	0	7(4)	8
	Albany	P	12	9	0(4)	0	0(4)	0
	Buffalo	P	NA	7	NA	0	NA	0
	Massena	P	17	12	0	0	24	23
	Newburg	P	18	12	0(4)	0	0(4)	0
	New York City	P	18	12	0(3)	0	0(3)	0
	Syracuse	P	18	9	0(2)	0	0(2)	0
N.C:	Charlotte[c]	P	16	15	0(4)	0	15(4)	12
N. Dak:	Minot[c]	P	11	11	0(4)	0	14(4)	14
Ohio:	Cincinnati[c]	P	9	9	0(4)	0	7(4)	6
	Cleveland[c]	P	9	9	0(4)	0	6(4)	8
Okla:	Oklahoma City[c]	P	7	10	0(4)	0	12(4)	7
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland[c]	P	3	7	0(4)	0	0(4)	14
	Baker	P	NA	3	(e)	(e)	18	5
	Coos Bay	P	NA	10	(e)	(e)	30	15
	Eugene	P	NA	4	(e)	(e)	(e)	14
	Medford	P	NA	2	(e)	(e)	(e)	10
	Portland composite	P	NA	5	(e)	(e)	(e) (4)	8
	Portland local	P	NA	5	(e)	(e)	(e) (4)	9
	Redmond	P	NA	2	(e)	(e)	(e)	6
	Tillamook	R	NA	8	(e)	(e)	25	27
Pa:	Philadelphia[c]	P	8	10	0(4)	0	7(4)	8
	Pittsburgh[c]	P	12	12	0(4)	0	7(4)	11
	Dauphin	P	7	7	0	0	20	16
	Erie	P	10	13	0	0	17	22
	Philadelphia	P	8	10	0	0	0(2)	16
	Pittsburgh	P	14	12	0	0	14	16
R.I:	Providence[c]	P	8	11	0(4)	0	15(4)	19
S.C:	Charleston[c]	P	12	14	0(4)	0	20(4)	25
S. Dak:	Rapid City[c]	P	4	9	0(4)	0	6(4)	10
Tenn:	Chattanooga[c]	P	11	13	0(4)	0	16(4)	13
	Memphis[c]	P	5	11	0(4)	0	13(4)	6
	Chattanooga	P	11	11	0(4)	0	22(4)	17
	Clinton	P	12	13	0(2)	0	19(2)	19
	Knoxville	P	7	10	0(2)	2	12(2)	14
	Nashville	P	8	9	0(2)	0	0(2)	10
Tex:	Austin[c]	P	0	3	0(4)	0	0(4)	2
	Dallas[c]	P	6	8	0(4)	0	10(4)	8
	Amarillo	R	NS	4	NS	0	NS	2
	Corpus Christi	R	3	4	0	0	0	2
	El Paso	R	2	2	0	0	0	0
	Fort Worth	R	NS	6	NS	0	NS	7
	Harlingen	R	NS	4	NS	0	NS	0
	Houston	R	NS	10	NS	0	NS	19
	Lubbock	R	3	4	0	0	0	2
	Midland	R	NS	3	0	0	0	0
	San Antonio	R	NS	3	NS	0	NS	0
	Texarkana	R	NS	12	NS	0	NS	16
	Uvalde	R	NS	2	NS	0	NS	0
	Wichita Falls	R	6	9	0	0	10	2
Utah:	Salt Lake City[c]	P	6	5	0(4)	0	6(4)	11
Vt:	Burlington[c]	P	9	10	0(4)	0	15(4)	10
Va:	Norfolk[c]	P	10	11	0(4)	0	10(4)	10
Wash:	Seattle[c]	P	8	8	0(4)	0	14(4)	21
	Spokane[c]	P	6	6	0(4)	0	5(4)	10
	Benton County	R	NS	0	NS	0	NS	6
	Franklin County	R	0	0	0	0	0	0
	Sandpoint, Idaho	R	9	9	0	0	16	25
	Skagit County	R	5	5	0	0	0	13
W.Va:	Charleston[c]	P	7	12	0(3)	0	10(3)	6
Wisc:	Milwaukee[c]	P	7	7	0(4)	0	16(4)	11
Wyo:	Laramie[c]	P	6	4	0(3)	0	13(3)	11
CANADA								
Alberta:	Calgary	P	8	8	(d)		13	18
	Edmonton	P	7	8	(d)		14	20
British Columbia:	Vancouver	P	12	14	(d)		33	49
Manitoba:	Winnipeg	P	5	8	(d)		25	25
New Brunswick:	Frederickton	P	13	15	(d)		15	23
Newfoundland:	St. Johns	R	16	20	(d)		26	42
Nova Scotia:	Halifax	R	10	12	(d)		13	22
Ontario:	Ft. William	P	15	16	(d)		25	31
	Ottawa	P	9	9	(d)		15	19
	Sault Ste. Marie	P	16	15	(d)		32	33

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for February 1969 and 12-month period, March 1968 through February 1969—Continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA—Continued								
Ontario:	Toronto	P	5	5	([d])		13	15
	Windsor	P	6	6	([d])		10	13
Quebec:	Montreal	P	7	9	([d])		19	21
	Quebec	P	11	12	([d])		25	29
Saskatchewan:	Regina	P	7	7	([d])		15	17
	Saskatoon	P	9	9	([d])		14	18
CENTRAL AND SOUTH AMERICA								
Columbia:	Bogota	P	NS	1	NS	0	NS	0
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	NA	0	0	0	0	0
Jamaica:	Mandeville	P	3	6	0	0	40	105
Venezuela:	Caracas	P	0	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	0	2	0(4)	1	15(4)	12
Puerto Rico:	San Juan[c]	P	4	5	0(4)	0	3(4)	9
PMN network averages[f]			7	9	0	0	10	12

[a] P, pasteurized milk; R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS pasteurized milk network stations denoted by footnote [c].
NA no analysis.
NS, no sample collected.

the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3 since levels at the great majority of the stations for February 1969 were below the respective practical reporting levels. Table 4 gives monthly averages for those stations at which barium-140 was detected.

Table 4. Barium-140 in milk, February 1969

Sampling location		Monthly average (pCi/liter)
		Barium-140
Calif:	Humboldt (State)	20
	Los Angeles (State)	13
	Mendocino (State)	13
	Sacramento (State)	15
	Shasta (State)	13

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 18 pCi/liter in the United States for the month of February 1969 and the highest 12-month average was 20 pCi/liter (Little Rock, Ark., New Orleans, La., and Duluth, Minn.) representing 10.0 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137

monthly averages ranged from 0 to 108 pCi/liter in the United States for the month of February 1969 and the highest 12-month average was 14 pCi/liter (Southeast Fla.), representing 3.2 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 results for individual samples were all below the practical reporting level.

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Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological
Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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FOOD AND DIET SURVEILLANCE

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	January–March 1968	October 1968
Connecticut Diet Study	January–June 1968	November 1968
Institutional Diet, *PHS*	July–September 1968	April 1969
Tri-City Diet, *HASL*	January–June 1968	April 1969

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below:

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Last presented
California	July–December 1967	November 1968
Colorado River Basin	1967	December 1968
Drinking Water Analyses Program	1961–1966	August 1968
Florida	1967	February 1969
Kansas	July–December 1967	November 1968
Minnesota	January–June 1968	February 1969
New York	January–June 1968	April 1969
Radiostrontium in Tap Water, HASL	January–June 1967	April 1969
Washington	July 1966–June 1967	August 1968

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Radioactivity in Washington Surface Water[1], July 1967-June 1968

Washington State Department of Health

Radioanalysis of surface water samples collected throughout the State of Washington is one of the major functions of the Washington State Department of Health radiation surveillance program. Most surface water samples are collected quarterly or semiannually by the Washington State Pollution Control Commission. Selected stations on the Columbia River are sampled weekly or monthly by local health departments. Cedar River, a major water supply for the greater Seattle area, is sampled monthly by the City of Seattle Water Department.

[1] Summarized from "Environmental Radiation Surveillance, Quarterly Reports and Sixth Annual Report."

All surface water samples are collected as grab samples in 2-liter polyethylene bottles. To prevent loss of radioactivity to the container, 2 milliliters of concentrated nitric acid are added to the sample before shipment to the State laboratory in Seattle for analysis.

Analytical procedures

Surface water samples are divided into two groups; those samples coming from the Columbia River, and those samples coming from waters other than the Columbia River. The latter samples are placed in stainless-steel Marinelli beakers for gamma-ray spectroscopy analysis as soon after receipt as possible. Distilled water is added when

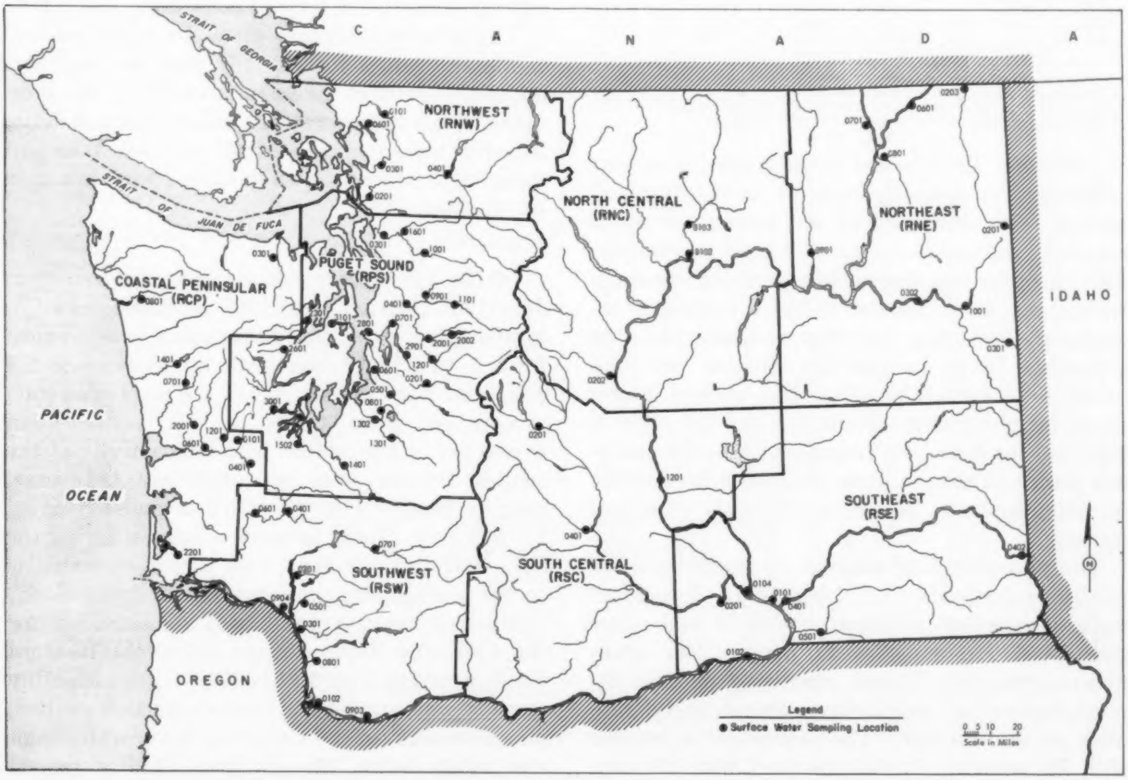

Figure 1. Washington surface water sampling locations with code numbers

necessary to obtain a standardized counting geometry of 2 liters. Table 1 gives the gamma-ray efficiencies and detection limits for the gamma-ray spectrometer. After gamma-ray analysis, the samples are filtered through Whatman No. 42 filter paper. The filter paper containing the suspended solids is ashed in a muffle furnace, transferred to a tared planchet, weighed, and counted for gross beta radioactivity. The filtrate is evaporated to near dryness, quantitatively transferred to a tared planchet, dried, weighed, and counted for gross beta radioactivity.

Table 1. Beta-particle and gamma-ray efficiencies and detectability limits for the Washington State analysis

Radionuclide	Energy band (MeV)	Efficiency (percent)	Average background (cpm)	Detectability limits (pCi)
Beta-particle emitters:				
Strontium-90–yttrium-90		34	0.5	[a] 0.31
Yttrium-90		38	.5	[a] .28
Phosphorus		35	.5	[a] .30
Gamma-ray emitters:				
Chromium-51	0.30–0.36	0.52	23.18	[b] 200
Ruthenium-106	.44– .56	.91	22.36	[b] 100
Cesium-137	.62– .72	2.75	11.18	[b] 30
Zirconium-95	.73– .79	6.96	5.72	[b] 10
Zinc-65	1.05–1.17	1.06	6.38	[b] 40

[a] Amount of radiation necessary to produce a net cpm equal to 2 sigma of background, based on 100 minute counts.
[b] Amount of radiation necessary to produce a net cpm equal to 4 sigma of the respective background, based on 100 minute counts.

Columbia River water is analyzed for gamma radioactivity approximately 14 days after collection. This delay allows the short-lived radionuclides, sodium-24, arsenic-76, and neptunium-239 to decay, leaving a less complex spectrum which can be evaluated without computer assistance. Following gamma radioanalysis the Columbia River samples are divided into two aliquots for further analysis. One aliquot is prepared for phosphorus-32 analysis and the other is analyzed for gross beta radioactivity by the methods described above. Gross beta-particle counting for all samples is performed 18 days after collection.

The phosphorus-32 analysis, a modification of published methods (*1–4*), begins 15 days after sample collection to allow arsenic-76 and other short-lived radionuclides to decay. The phosphorus is separated from interfering nuclides by precipitation as ammonium phosphomolybdate from an acid medium. The precipitate is washed with ammonium nitrate, dissolved with 3$\underline{N}$ ammonium hydroxide, transferred to a tared planchet, dried, ashed at 450°C., and counted for beta radioactivity.

Results

Table 2 presents the monthly average results for seven Columbia River stations which are sampled routinely. In averaging, a less-than value is assumed to be equal to its numerical value and a less-than sign is placed in front of the average.

Table 3 summarizes the beta radioactivity measurements from 27 other surface water stations from July 1967 through June 1968. The second column in this table gives code numbers and the abbreviations denoting geographical sections (figure 1). Each river is assigned a four digit number; the first two digits indicate the river and the second two digits indicate the sampling stations on the river. For example, code number 04 refers to the Snake River in the area designated "RSE", i.e., Southeast. The code number 01 refers to the first sampling station on that river. The third column gives the total number of samples analyzed. Gross beta radioactivity results are not extrapolated to the date of collection.

The network summary gives the maximum and minimum values for the 161 samples analyzed, while the network average is obtained by averaging all the station average values. Gamma radioactivity measurements of all samples taken at sampling locations shown in table 3 were less than 5 cpm/liter.

Discussion

Of the 161 river water samples analyzed from July 1967 through June 1968 (excluding the Columbia River), the total beta radioactivity ranged from 1 to 32 pCi/liter with an average of 2.9 pCi/liter. The radioactivity of the suspended fraction ranged from <1 to 28 pCi/liter with an average of <1 pCi/liter. The radioactivity of the soluble fraction was approximately the same, ranging from <1 to 10 pCi/liter and averaging 1.7 pCi/liter. These network averages during the July 1967 through June 1968 period were similar to the averages for the preceding 12 months.

Monthly average total beta radioactivity for the Columbia River stations below the Hanford Facility ranged from 10 to 545 pCi/liter. Monthly average concentrations of the beta-particle emitter, phosphorus-32, in the Columbia River water samples taken below the Hanford Facility ranged from 5 to 317 pCi/liter.

Table 2. Monthly average radioactivity in Columbia River water, July 1967–June 1968

Location and type of analysis	Concentration (pCi/liter) 1967 July	Aug	Sept	Oct	Nov	Dec	1968 Jan	Feb	Mar	Apr	May	June
McNary Dam (code No. RSE 0102)												
Beta-particle												
Suspended[a]	15	16	NS	6	16	NS	20	14	19	19	65	17
Dissolved[a]	35	30	NS	58	48	NS	43	55	56	50	79	15
Total[a]	50	46	NS	64	64	NS	63	69	75	69	144	32
Phosphorus-32[b]	41	NA	NS	66	47	NS	43	54	81	66	135	15
Gamma-ray[b]												
Chromium-51	1,256	1,933	NS	2,434	1,449	NS	1,574	913	1,169	606	1,617	211
Ruthenium-106[c]	<50	<50	NS	<50	<50	NS	<50	<50	<50	<50	<50	<50
Zirconium-95	<5	<5	NS	<5	<5	NS	<5	<5	<5	<5	<5	<5
Zinc-65	37	26	NS	28	<20	NS	51	36	73	42	56	25
Scandium-46	17	13	NS	23	35	NS	45	32	40	22	93	27
Northport (code no. RNE 0601)												
Beta-particle												
Suspended[a]	NS	<1	NS	NS	NS	<1	NS	NS	<1	NS	<1	NS
Dissolved[a]	NS	2	NS	NS	NS	3	NS	NS	2	NS	2	NS
Total[a]	NS	<3	NS	NS	NS	<4	NS	NS	<3	NS	<3	NS
Phosphorus-32[b]	NS	<1	NS	NS	NS	<1	NS	NS	<1	NS	<1	NS
Gamma-ray[b]												
Chromium-51	NS	<100	NS	NS	NS	<100	NS	NS	<100	NS	<100	NS
Ruthenium-106[c]	NS	<50	NS	NS	NS	<50	NS	NS	<50	NS	<50	NS
Zirconium-95	NS	<5	NS	NS	NS	<5	NS	NS	<5	NS	<5	NS
Zinc-65	NS	<20	NS	NS	NS	<20	NS	NS	<20	NS	<20	NS
Scandium-46	NS	<10	NS	NS	NS	<10	NS	NS	<10	NS	<10	NS
Richland (code no. RSE 0104)												
Beta-particle												
Suspended[a]	38(2)	250(2)	31(2)	47(2)	287	40	35(2)	36(2)	42	37(2)	142(2)	27(2)
Dissolved[a]	66(2)	134(2)	95(2)	129(2)	258	178	139(2)	186(2)	179(2)	163	125(2)	54(2)
Total[a]	104	384	126	176	545	218	174	222	221	200	267	81
Phosphorus-32[b]	46(2)	193	79(2)	91(2)	168	91	102(2)	165(2)	169(2)	129(2)	206(2)	45(2)
Gamma-ray[b]												
Chromium-51	2,012(2)	4,492(2)	3,130(2)	5,304(2)	7,346	5,890	3,102(2)	3,025(2)	2,823(2)	1,347(2)	2,331(2)	947(2)
Ruthenium-106[c]	<100(2)	<100(2)	<100(2)	<100(2)	<100	<100	<100(2)	<100(2)	<100(2)	<100(2)	<100(2)	<100(2)
Zirconium-95	<10(2)	<14(2)	<10(2)	<10(2)	<10(2)	<10	<10(2)	<10(2)	<10(2)	<10(2)	<10(2)	<10(2)
Zinc-65	75(2)	267(2)	58(2)	155(2)	339	128	114(2)	142(2)	145(2)	96(2)	146(2)	51(2)
Scandium-46	69(2)	194(2)	79(2)	86(2)	499	126	99(2)	90(2)	257(2)	86(2)	165(2)	68(2)
Pasco (code no. RSE 0101)												
Beta-particle												
Suspended[a]	26	59	114	107	41	72	75	38	71	52	219	62
Dissolved[a]	31	70	95	196	94	104	122	137	163	134	217	96
Total[a]	57	129	209	303	135	176	197	175	234	186	436	158
Phosphorus-32[b]	13	48	80	182	79	98	140	149	212	203	317	150
Gamma-ray[b]												
Chromium-51	1,004	2,979	4,437	5,570	2,771	3,145	3,852	1,792	2,743	1,782	4,806	1,393
Ruthenium-106[c]	73	<50	102	149	58	<50	<50	73	96	<50	107	<50
Zirconium-95	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Zinc-65	41	107	122	134	84	97	117	79	127	105	164	85
Scandium-46	17	76	111	129	90	105	167	100	135	86	194	83
Wanapum Dam (code no. RSC 1201)												
Beta-particle												
Suspended[a]	<1	<1	<1	<1	<1	NS	<1	<1	NS	NS	NS	NS
Dissolved[a]	2	2	2	2	2	NS	2	3	NS	NS	NS	NS
Total[a]	<3	<3	<3	<3	<3	NS	<3	<4	NS	NS	NS	NS
Phosphorus-32[b]	<1	<1	<1	<1	<1	NS	<1	<1	NS	NS	NS	NS
Gamma-ray[b]												
Chromium-51	<100	<100	<100	<100	<100	NS	<100	<100	NS	NS	NS	NS
Ruthenium-106[c]	<50	<50	<50	<50	<50	NS	<50	<50	NS	NS	NS	NS
Zirconium-95	<5	<5	<5	<5	<5	NS	<5	<5	NS	NS	NS	NS
Zinc-65	<20	<20	<20	<20	<20	NS	<20	<20	NS	NS	NS	NS
Scandium-46	<10	<10	<10	<10	<10	NS	<10	<10	NS	NS	NS	NS
Vancouver (code no. RSW 0102)												
Beta-particle												
Suspended[a]	21(4)	15	8(3)	6(3)	11(3)	31(2)	23(2)	14	NS	18(4)	24(3)	13(2)
Dissolved[a]	24(4)	22	24(3)	29(3)	25(3)	29(2)	21(2)	43	NS	25(4)	37(3)	15(2)
Total[a]	45	37	32	35	36	50	44	57	NS	42	61	28
Phosphorus-32[b]	23(4)	19	13(3)	18(3)	25(3)	25(2)	19(2)	41	NS	27(4)	54(3)	18(2)
Gamma-ray[b]												
Chromium-51	1,032(4)	1,325	1,692(3)	1,300(3)	1,369(3)	1,337(2)	770(2)	1,132	NS	421(4)	880(3)	261(2)
Ruthenium-106[c]	<50(4)	<50	<50(3)	<50(3)	<50(2)	<50(2)	<50(2)	<50	NS	<50(4)	<50(3)	<50(2)
Zirconium-95	<5(4)	<5	<5(3)	<5(3)	<5(2)	<5(2)	<5(2)	<5	NS	<5(4)	<5(3)	<5(2)
Zinc-65	39(4)	<20	<25(3)	<20(3)	<26(2)	<26(2)	23(2)	24	NS	<23(4)	31(3)	<20(2)
Scandium-46	18(4)	11	<10(3)	<10(3)	<12(2)	32(2)	30(2)	34	NS	32(4)	26(3)	24(2)
Longview (code No. RSW 0904)												
Beta-particle												
Suspended[a]	10(4)	6(5)	7(4)	7(4)	7(5)	4(4)	6(5)	4(4)	7(4)	7(2)	13(5)	11(4)
Dissolved[a]	14(4)	15(5)	17(4)	22(4)	15(5)	6(4)	10(5)	7(4)	15(4)	10(2)	20(5)	10(4)
Total[a]	24	21	24	29	22	10	16	11	22	17	33	21
Phosphorus-32[b]	14(4)	11(3)	10(4)	12(4)	14(5)	5(4)	9(5)	6(4)	20(4)	11(2)	25(5)	12(4)
Gamma-ray[b]												
Chromium-51	575(4)	917(5)	1,330(4)	1,046(4)	769(5)	279(4)	<345(5)	162(4)	365(4)	176(2)	488(5)	191(4)
Ruthenium-106[c]	<50(4)	<50(4)	<50(4)	<50(5)	<50(5)	<50(4)	<50(5)	<50(4)	<50(4)	<50(2)	<50(5)	<50(4)
Zirconium-95	<5(4)	<5(5)	<6(4)	<5(4)	<5(5)	<5(4)	<5(5)	<5(4)	<5(4)	<5(2)	<5(5)	<5(4)
Zinc-65	<29(4)	<26(5)	<22(4)	<20(4)	<21(5)	<20(4)	<20(5)	<21(4)	<20(4)	<20(2)	<23(5)	<20(4)
Scandium-46	<11(4)	<10(5)	<10(4)	<11(4)	<10(5)	<10(4)	<11(5)	<10(4)	<12(4)	13(2)	<11(5)	<14(4)

[a] Activity at time of counting. Strontium-90 yttrium-90 calibration standard.
[b] Results extrapolated to date of sample collection.
[c] Net activity in the 0.44–0.56 MeV gamma-range is assumed to be only ruthenium-106.
NS, no sample reported.

Table 3. Beta radioactivity in Washington surface water (except for Columbia River) July 1967–June 1968

Sampling location	Code number		Number of samples	Concentration (pCi/liter)								
				Suspended			Dissolved			Total		
				Average[a]	Minimum	Maximum	Average[a]	Minimum	Maximum	Average[a]	Minimum	Maximum
Cedar River	RPS	0201	12	<1	<1	<1	<1	<1	2	1	1	3
Colville River	RNE	0801	1	<1			4			5		
Kettle River	RNE	0701	1	<1			1			2		
Klickitat River	RSC	1301	7	<1	<1	2	1	1	2	2	2	4
Lake Whatcom	RNW	0601	9	<1	<1	1	3	2	4	4	3	5
Lewis River	RSW	0801	11	<1	<1	1	<1	<1	1	1	1	2
Little Spokane River	RNE	1001	1	<1			2			3		
Naches River	RSC	0401	11	<1	<1	<1	1	<1	2	2	1	3
Naselle River	RCP	2201	10	<1	<1	<1	<1	<1	2	1	1	3
Nisqually River	RPS	1401	5	1	<1	2	1	1	2	2	2	4
Nooksack River	RNW	0101	4	2	<1	4	2	1	2	4	2	6
Okanogan River	RNC	0103	4	1	<1	2	2	2	3	3	3	5
Pend Oreille River	RNE	0201	11	<1	<1	1	2	2	3	3	3	4
Puyallup River	RPS	1302	11	6	<1	28	2	1	4	8	2	32
Satsop River	RCP	1201	2	<1	<1	<1	<1	<1	1	1	1	2
Skagit River	RNW	0201	12	<1	<1	2	2	1	2	3	2	4
Snake River	RSE	0401	8	1	<1	6	4	2	5	5	3	11
Snohomish River	RPS	0401	3	<1	<1	1	1	1	2	2	2	3
Snoqualmie River, South Fork	RPS	0000	1	<1			1			2		
Spokane River	RNE	0301	7	1	<1	5	2	1	3	3	2	8
Sultan River	RPS	0901	3	<1	<1	<1	2	1	2	3	2	3
Tolt River	RPS	2001	3	<1	<1	<1	<1	<1	1	1	1	2
Toutle River	RSW	0201	4	<1	<1	<1	1	1	1	2	2	2
Walla Walla River	RSE	0501	3	3	<1	7	6	4	10	9	5	17
Wenatchee River	RNC	0202	4	<1	<1	<1	2	2	2	3	3	3
Wishkah River	RCP	2001	9	<1	<1	1	<1	<1	1	1	1	2
Yakima River	RSC	0201	4	<1	<1	<1	<1	<1	1	1	1	2
Network summary			161	<1	<1	28	1.7	<1	10	2.9	1	32

[a] For averaging purposes, <1 is assumed to be equal to 0.5 pCi/liter. Averages less than 1 are recorded as <1.

The gamma-ray emitters, ruthenium-106 and zirconium-95, were found in monthly average concentrations that ranged from <50 to 149 pCi/liter for ruthenium-106, and <5 to <14 pCi/liter for zirconium-95. The values for ruthenium-106 were probably a combination of ruthenium-103 and ruthenium-106. Other radionuclides found in detectable quantities in Columbia River water were chromium-51, zinc-65, and scandium-46. Monthly averages for chromium-51 ranged from <100 to 7,346 pCi/liter, for zinc-65 the range was <20 to 339 pCi/liter, while scandium-46 ranged from <10 to 499 pCi/liter.

Although any standards for gross beta radioactivity must be very carefully applied, the standard for drinking water is 1,000 pCi/liter of gross beta radioactivity in the absence of strontium-90 and alpha-particle emitters (*5*). The standards for water from all dietary sources for the general population at large (*6*) are: chromium-51, 670,000 pCi/liter; ruthenium-106, 3,300 pCi/liter; zinc-65, 10,000 pCi/liter; phosphorus-32, 7,000 pCi/liter; and scandium-46, 13,000 pCi/liter.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July 1965–June 1966	August 1967
July 1966–June 1967	August 1968

REFERENCES

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Tritium in Surface Water Network, July-December 1968

Bureau of Radiological Health
U.S. Public Health Service

The tritium sampling network was established by the Public Health Service in May 1964 to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at selected surface water stations downstream from nuclear facilities. The network consists of 10 stations selected from the 131 existing water pollution sampling stations operated by the Federal Water Pollution Control Administration (FWPCA); eight of the stations are located downstream from nuclear facilities and two stations serve to establish baseline levels (figure 1). Reports covering the period, 1964–1965 (*1*) and 1966 (*2*) have been published previously in *Radiological Health Data and Reports*.

Monthly composites of weekly samples are collected through the FWPCA and sent to the Southeastern Radiological Health Laboratory for analysis. The analyses are carried out using liquid scintillation counting techniques described by Moghissi et al (*3*). The minimum level of detectability is 0.2 nCi/liter.

Data for the samples collected during the last 6 months of 1968 are shown in table 1. Station

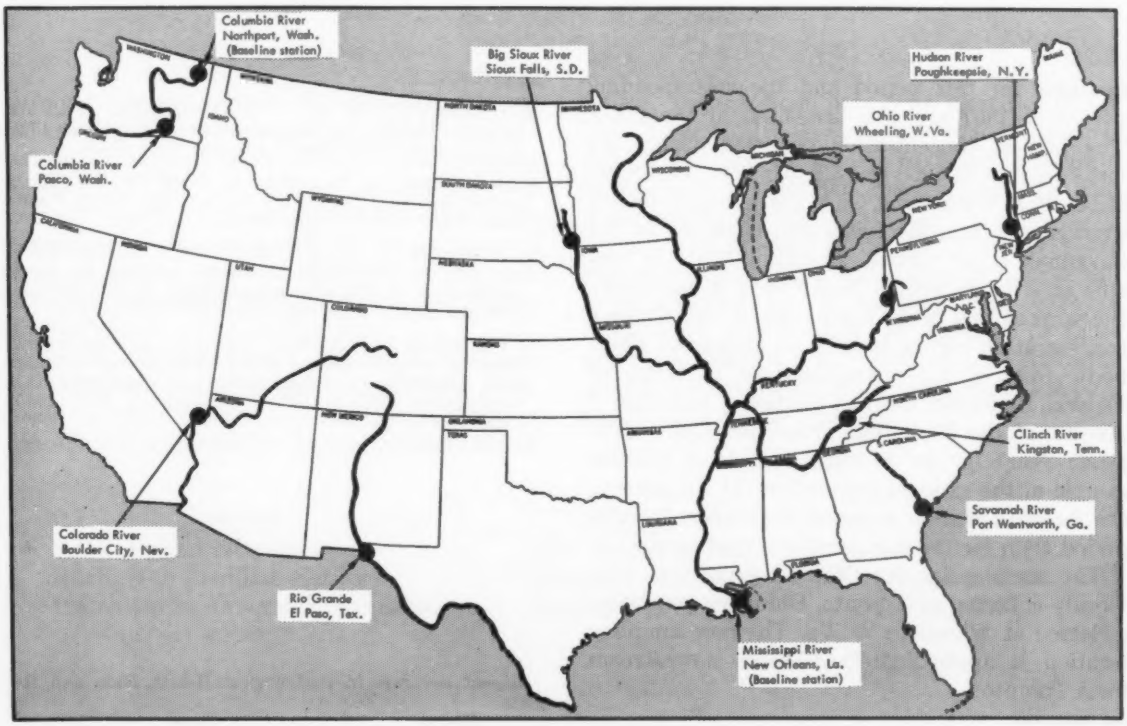

Figure 1. Sampling stations for tritium in surface waters

Table 1. Tritium concentration in surface waters, July–December 1968

Collection site	Concentration[a] (nCi/liter)							
	July	August	September	October	November	December	July–December average[b]	
							1968	1969
Big Sioux River: Sioux Falls, S.Dak	0.3±0.2	0.4±0.2	0.3±0.2	NS	NS	NS	0.3	0.8
Clinch River: Kingston, Tenn	4.1±0.3	.4±0.2	.6±0.2	NS	NS	NS	1.7	5.4
Colorado River: Boulder City, Nev	NS	2.0±0.2	1.7±0.2	NS	NS	1.6±0.2	1.8	2.3
Columbia River: Northport, Wash[d]	NS	NS	NS	NS	0.8±0.2	NS		
Columbia River: Pasco, Wash	.9±0.2	NS	.9±0.2	NS	.6±0.2	NS	.8	1.1
Hudson River: Poughkeepsie, N.Y	.6±0.2	[c]2±0.2	.8±0.2	NS	.4±0.2	NS	.5	.8
Mississippi River: New Orleans, La[d]	.8±0.2	.4±0.2	.5±0.2	NS	NS	NS	.6	.6
Ohio River: Wheeling, W.Va	NS	NS	NS	NS	NS	.2±0.2		
Rio Grande: El Paso, Tex	NS	NS	NS	NS	NS	[c].2±0.2		.3
Savannah River: Port Wentworth, Ga	8.9±0.4	5.9±0.3	5.8±0.5	NS	NS	NS	6.9	5.6

[a] The error reported is the 2-sigma counting error.
[b] Values less than or equal to the minimum level of detectability (0.2 nCi/liter) were averaged as zero.
[c] Values are not statistically significant at the 95-percent confidence level.
[d] Baseline station.

averages for this period and the corresponding period of 1967 are also presented in the table. The highest concentration observed during the last 6 months of 1968 was 8.9 nCi/liter (Savannah River–Port Wentworth, Ga.). The highest 6-month average, 6.9 nCi/liter, was also observed at the Savannah River station. Assuming that the specific activity of tritium in the body is essentially the same as that in the surface water, this average concentration corresponds to an estimated whole body dose[1] of 1.2 mrem/year; or in terms of Federal Radiation Council guidance, less than 1 percent of the Radiation Protection Guide (170 mrem/year) for an average dose to a suitable sample of the exposed population (*4*). In general, the 6-month station averages were lower for this period than for the comparable period in 1967.

The samples for the Ohio River station, previously collected at Toronto, Ohio, are now being collected at Wheeling, W. Va. The new sampling location is approximately 50-miles downstream from Toronto.

[1] Development of the calculations to obtain this dose may be found in reference 2.

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(*1*) CHESNUTT, M. W., J. C. DROBINSKI, JR., and R. H. GORRIE. Tritium in surface waters, 1964–1965. Radiol Health Data Rep 7:377–380 (July 1966).

(*2*) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 7:337–339 (July 1968).

(*3*) MOGHISSI, A. A., H. L. KELLEY, J. E. REGNIER, and M. W. CARTER. Low-level counting by liquid scintillation. 1. Tritium measurement in homogeneous systems. Inter J Appl Rad Isotopes 20:145 (1969).

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Recent coverage in Radiological Health Data and Reports:

Period	Issue
January–December 1967	October 1968
January–June 1968	November 1968

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

1. Radiation Alert Network
February 1969

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during February 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, February 1969

Station location		Number of samples: Air	Air surveillance gross beta radioactivity (pCi/m³): Maximum	Minimum	Average [a]	Last profile in RHD&R	Precipitation: Number of samples	Total depth (mm)	Field estimation of deposition: Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	19	4	0	1	Sept 68	5	102	5	102	24
Alaska:	Adak	26	2	1	2	Feb 69	(c)	1			
	Anchorage	7	0	0	0	Oct 68	1		(d)		
	Attu Island	3	0	0	0	Mar 69	(c)				
	Fairbanks	(b)				Nov 68	(c)				
	Juneau	8	0	0	0	Dec 68	5	28	5	28	0
	Kodiak	5	0	0	0	Jan 69	(c)				
	Nome	(b)				May 69	(c)				
	Point Barrow	28	0	0	0	Apr 69	(c)				
	St. Paul Island	4	1	1	1	June 69	(c)				
Ariz:	Phoenix	17	12	1	5	Dec 68	(c)				
Ark:	Little Rock	10	4	0	1	Oct 68	(c)				
Calif:	Berkeley	19	1	0	0	Jan 69	13	198	13	198	0
	Los Angeles	4	1	0	0	May 69	(c)				
C.Z:	Ancon	15	0	0	0	Jan 69	(c)				
Colo:	Denver	18	10	1	4	Jan 69	(c)				
Conn:	Hartford	17	0	0	0	Nov 68	8	40	8	40	0
Del:	Dover	16	1	0	0	Sept 68	(c)				
D.C:	Washington	9	1	0	1	Apr 69	(c)				
Fla:	Jacksonville	12	2	0	1	Oct 68	3	25	3	25	22
	Miami	16	1	0	0	Nov 68	1	50	1	50	0
Ga:	Atlanta	19	1	1	1	June 69	2	50	2	50	74
Guam:	Agana	(b)				Sept 69	(c)				
Hawaii:	Honolulu	26	1	0	0	Mar 69	4	50	(d)		
Idaho:	Boise	22	2	0	0	Mar 69	8	62	8	62	52
Ill:	Springfield	17	1	0	0	Apr 69	(c)				
Ind:	Indianapolis	18	2	0	1	June 69	3	24	3	24	19
Iowa:	Iowa City	21	0	0	0	Jan 69	1	6	1	6	0
Kans:	Topeka	20	1	0	0	Oct 68	4	9	4	9	0
Ky:	Frankfort	12	1	0	1	Apr 69	(c)				
La:	New Orleans	18	1	0	0	Apr 69	8	95	(d)		
Maine:	Augusta	16	1	0	0	May 69	6	233	6	233	0
Md:	Baltimore	18	1	0	0	Nov 69	2	20	2	20	0
	Rockville	10	0	0	0	Mar 69	(c)				
Mass:	Lawrence	17	0	0	0	Jan 69	3	89	3	89	0
	Winchester	13	0	0	0	Feb 69	6	127	6	127	0
Mich:	Lansing	20	0	0	0	Mar 69	(c)				
Minn:	Minneapolis	10	0	0	0	Sept 68	1	2	1	2	0
Miss:	Jackson	19	1	0	0	May 69	3	92	3	92	59
Mo:	Jefferson City	18	1	0	0	June 69	6	48	6	48	0
Mont:	Helena	19	2	0	1	Feb 69	2	8	2	8	7
Nebr:	Lincoln	20	1	0	1	June 69	1	2	1	2	1
Nev:	Las Vegas	12	2	0	1	Nov 68	(c)				
N.H:	Concord	18	1	0	0	Apr 69	(c)				
N.J:	Trenton	20	0	0	0	May 69	4	63	4	63	29
N. Mex:	Santa Fe	12	2	0	1	Feb 69	4	6	2	6	4
N.Y:	Albany	12	2	0	1	June 69	5	28	5	28	38
	Buffalo	18	0	0	0	Jan 69	(c)				
	New York City	17	0	0	0	Feb 69	(c)				
N.C:	Gastonia	14	4	1	2	Jan 69	1	5	(d)		
N.Dak:	Bismarck	18	0	0	0	Apr 69	7	78	6	58	0
Ohio:	Cincinnati	(b)				Sept 68	(c)				
	Columbus	17	2	0	0	May 69	2	26	2	26	0
	Painesville	19	1	0	0	Nov 68	2	2	2	2	2
Okla:	Oklahoma City	18	2	0	1	Mar 69	4	75	4	75	0
	Ponca City	20	2	0	1	Nov 68	4	37	4	37	0
Ore:	Portland	18	1	0	0	June 69	6	52	6	52	17
Pa:	Harrisburg	14	0	0	0	June 69	(c)				
P.R:	San Juan	(b)				May 69	(c)				
R.I:	Providence	18	2	0	0	Mar 69	4	31	4	31	11
S.C:	Columbia	11	1	0	0	Feb 69	4	63	4	63	13
S. Dak:	Pierre	16	1	0	0	Dec 68	(c)				
Tenn:	Nashville	6	1	0	0	Mar 69	5	62	5	62	13
Tex:	Austin	14	7	0	2	Sept 68	3	88	(d)		
	El Paso	21	7	0	3	Apr 69	(c)				
Utah:	Salt Lake City	28	1	0	0	May 69	7	62	7	62	6
Vt:	Barre	15	1	0	0	Oct 68	8	59	7	58	0
Va:	Richmond	18	1	0	0	Oct 68	2	70	2	70	35
Wash:	Seattle	19	0	0	0	Oct 68	8	46	(d)		
	Spokane	18	0	0	0	Sept 68	1	3	1	3	3
W. Va:	Charleston	20	2	0	0	Feb 69	3	33	3	33	4
Wisc:	Madison	20	1	0	0	Oct 68	2	4	2	4	5
Wyo:	Cheyenne	20	6	1	3	Nov 68	2	8	2	8	13
Network summary		1,097	12	0	1		4	50	4	51	12

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.

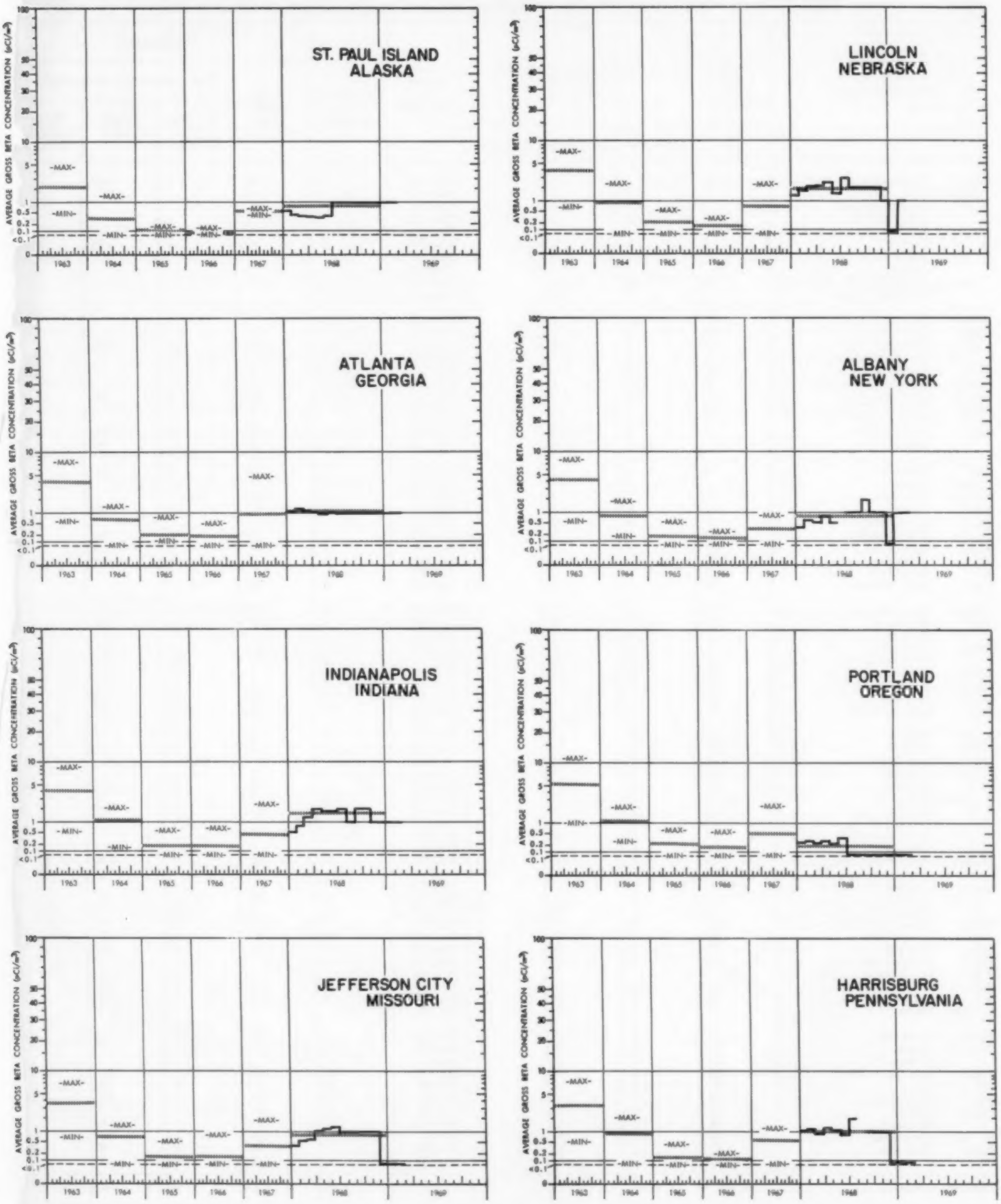

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network 1963–February 1969

2. Canadian Air and Precipitation Monitoring Program[1], February 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for February 1969 are presented in table 2.

[1] Prepared from information and data in the March 1969 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

The average deposition for 23 stations for January 1969 was 0.6 nCi/m^2 with a high of 1.5 nCi/m^2 occurring at Sault St. Marie and VanCouver and a low of 0.1 nCi/m^2 occurring at Resolute.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, February 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m^3)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m^2)
Calgary	28	0.2	0.0	0.1	NS	NS
Coral Harbour	28	.1	.0	.1	25	0.3
Edmonton	28	.1	.0	.1	21	.4
Ft. Churchill	27	.1	.0	.1	47	.2
Ft. William	28	.2	.0	.1	31	.4
Fredericton	28	.2	.0	.1	12	.6
Goose Bay	13	.1	.0	.1	68	2.5
Halifax	27	.1	.0	.1	13	1.2
Inuvik	28	.1	.0	.1	32	.3
Montreal	28	.1	.0	.1	15	.3
Moosonee	23	.1	.0	.1	4	.1
Ottawa	28	.2	.0	.1	6	.1
Quebec	28	.1	.0	.1	7	.2
Regina	28	.1	.0	.1	38	1.1
Resolute	26	.2	.0	.1	11	.1
St. John's, Nfld	26	.2	.0	.1	15	2.0
Saskatoon	28	.1	.0	.1	12	.2
Saulte Ste Marie	28	.1	.0	.1	15	.4
Toronto	28	.2	.0	.1	21	.3
Vancouver	28	.1	.0	.1	33	1.6
Whitehorse	28	.1	.0	.1	48	.3
Windsor	28	.1	.0	.1	60	.3
Winnipeg	28	.1	.0	.1	44	.4
Yellowknife	27	.2	.0	.1	21	.2
Network summary	27	0.1	0.0	0.1	26	0.6

NS, no sample.

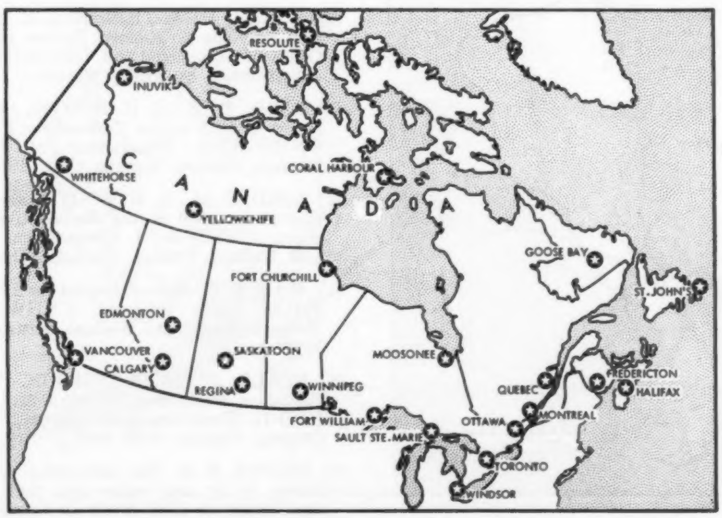

Figure 3. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program February 1969

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 4. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The February 1969 air monitoring results from the participating countries are given in table 3.

Figure 4. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, February 1969

Station location	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	18	0.38	0.13	0.26
Bolivia: La Paz	11	.06	.00	.04
Chile: Santiago	2	.21	.13	.17
Colombia: Bogota	15	.07	.01	.03
Ecuador: Guayaquil	16	.17	.06	.11
Guyana: Georgetown	13	.11	.02	.06
Jamaica: Kingston	16	.16	.04	.10
Peru: Lima	NS			
Venezuela: Caracas	15	.09	.01	.05
West Indies: Trinidad	14	.10	.02	.05
Pan American summary	120	0.38	0.00	0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m^3 are reported and used in averaging as 0.00 pCi/m^3.
NS, no sample.

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(*1*) PUBLIC HEALTH SERVICE. Environmental Radiation Surveillance Report. Bureau of Radiological Health, Office of Standards and Criteria, Rockville, Md. 20852 (Distribution by official request).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*4*) MAR, P. G. Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*5*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*6*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Radionuclides in Alaskan Caribou and Reindeer, September-November 1968

Bureau of Radiological Health
U.S. Public Health Service

Under a cooperative agreement between the Alaskan Department of Health and Welfare, the Alaskan Department of Fish and Game, and the U.S. Public Health Service, an active program of caribou and reindeer sampling and analysis was undertaken in 1963 to aid in the assessment of radionuclide intake of Alaskan residents. This joint sampling activity was continued based on the results of a limited sampling effort conducted by these groups in 1962.

Through the second quarter of 1964, the sampling was confined to the three principal caribou herds and one privately-owned reindeer herd. This program was expanded in September 1964, when

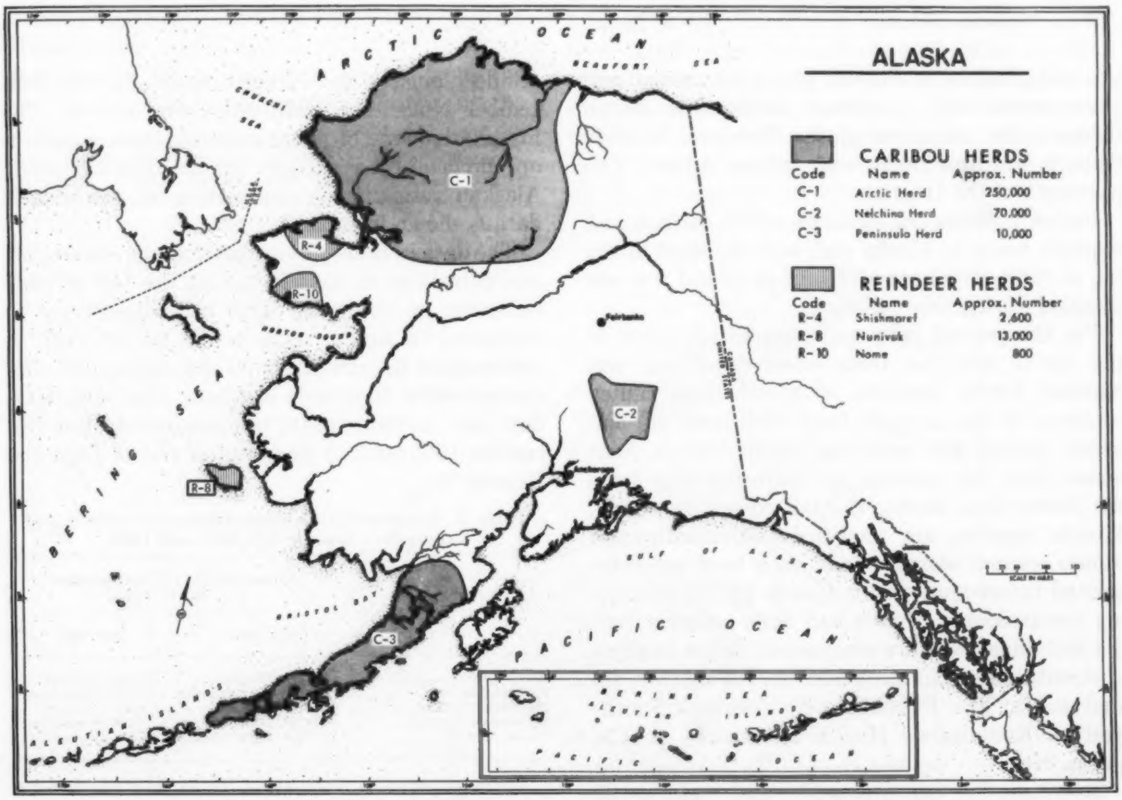

Figure 1. Locations of caribou and reindeer herds sampled in Alaska

Table 1. Radionuclide concentration in muscle and rumen of Alaskan caribou and reindeer September–November 1968

Herd and sampling locations[a]	Collection date 1968	Sex	Age (years)	Muscle (pCi/kg wet weight)			Rumen (pCi/kg wet weight)
				Strontium-89[b]	Strontium-90[b]	Cesium-137	Cesium-137
Arctic caribou herd Amaktuvuk Pass, C-1	10/1	F	3	13	4	4.6×10^3	5.1×10^3
	10/9	F	2			6.0×10^3	
	10/9	F	3			5.1×10^3	
	10/9	F	2			5.6×10^3	
	10/9	F	3			4.8×10^3	
Nelchina caribou herd Dickey Lake, C-2	9/11	F	9	[c] 0	7	2.6×10^3	3.8×10^3
	9/11	F	5			1.5×10^3	
	9/11	F	1			3.1×10^3	
	9/11	F	9			2.0×10^3	
	9/11	M	2			2.6×10^3	
Peninsula caribou herd King Salmon, C-3	10/1	M	(d)	0	5	13.0×10^3	5.1×10^3
	10/1	F	(d)			2.5×10^3	
	10/1	F	1			1.7×10^3	
	10/3	M	(d)			5.5×10^3	
	10/3	M	(d)			4.7×10^3	
Shishmaref reindeer herd Seward Peninsula, R-4	11/12	M	3	0	21	11.0×10^3	4.9×10^3
	11/12	F	3			13.0×10^3	
	11/12	M	3			9.7×10^3	
	11/12	M	4			11.0×10^3	
	11/12	F	2			11.0×10^3	
Nome reindeer herd, R-10	11/21	M	4	0	100	1.6×10^4	1.1×10^4
	11/21	M	3			1.3×10^4	
	11/21	F	5			2.1×10^4	
	11/21	M	1			2.1×10^4	
	11/21	M	2			2.2×10^4	

[a] Sampling locations are shown in figure 1.
[b] Composite of individual samples taken within herd.
[c] All results ≤ 5 pCi/kg wet weight are reported as 0.
[d] Ages not available.

the sampling of additional privately owned and government-owned reindeer herds was begun through the assistance of the Fish and Wildlife Service and the Bureau of Indian Affairs, Department of the Interior.

Figure 1 shows the locations of the caribou and reindeer herds in Alaska that were sampled in the fall of 1968. The herd at Nunivak Island was not sampled during this period.

For the present program, samples are taken in the spring and fall from selected caribou and reindeer herds. Samples of muscle and rumen contents of five animals from each herd are collected during the sampling period. Hock joint bones from five animals are collected only from the Nome herd during the fall collection period. Muscle samples are analyzed individually and rumen content samples from each herd are composited before analysis for cesium-137 by gamma-ray spectroscopy. Muscle and bone samples from the individual herd are composited before analysis of strontium-89 and strontium-90. All samples are analyzed at the Public Health Service's Southwestern Radiological Health Laboratory in Las Vegas, Nev.

Strontium-89, strontium-90, and cesium-137 data are presented in table 1 for caribou muscle, reindeer muscle, and rumen contents for the September–November 1968 collection period. The muscle data are of prime interest, since muscle is an important constituent of the diet for many Alaskan residents. A comparison of the muscle data is shown in table 2.

The data in table 2 indicates that the cesium-137 concentrations in muscle during the fall of 1968 remained at the same level of radioactivity as compared to similar data in the fall of 1967. A summary of the strontium-90 and cesium-137 concentrations in foodstuffs in Alaska (including reindeer and caribou meat) is contained in the December 1966 issue of *Radiological Health Data and Reports*.

Table 2. Cesium-137 concentrations in caribou and reindeer muscle fall 1967 and 1968

Herd	Average cesium-137 concentration (pCi/kg wet weight)	
	Fall 1967	Fall 1968
Arctic caribou	6×10^3 (October)	5×10^3 (October)
Nelchina caribou	6×10^3 (September)	2×10^3 (September)
Peninsula caribou	11×10^3 (October)	5×10^3 (October)
Shishmaref reindeer	11×10^3 (October)	11×10^3 (November)
Nome reindeer	14×10^3 (September)	19×10^3 (November)

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
March–May 1968	December 1968

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Oak Ridge Area and the Rocky Flats Plant.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Oak Ridge Area[2]
January-June 1968

Union Carbide Nuclear Company
Oak Ridge, Tenn.

Oak Ridge area is a complex made up primarily of the Y-12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ability to fix radioactive materials by an ion exchange mechanism. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to trenches located in the Conasauga shale formation. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

[2] Summarized from "Environmental Levels of Radioactivity for the Oak Ridge Area (Report Period. January–June 1968). Health Physics and Safety Section, Health Physics Division, Oak Ridge National Laboratory.

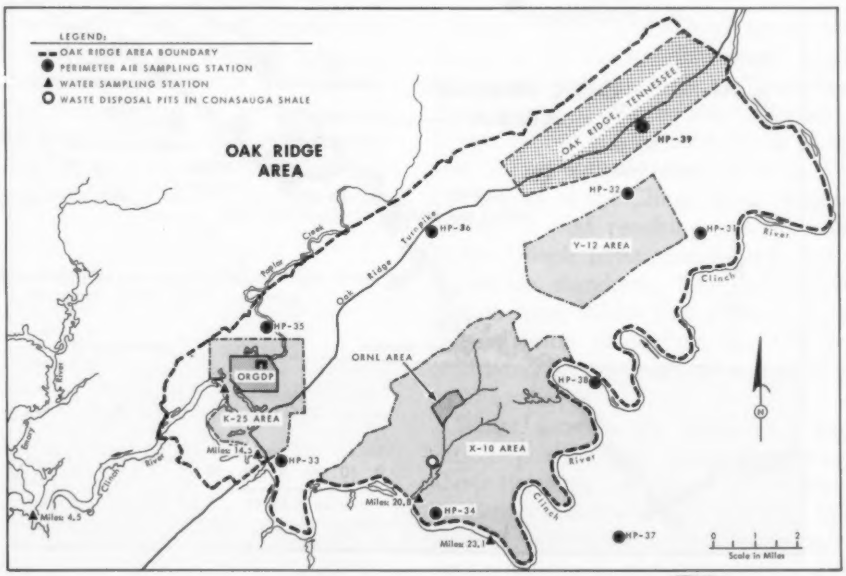

Figure 1. Oak Ridge area environmental sampling locations

Air monitoring

Atmospheric contamination by radioactive materials occurring in the general environment of East Tennessee is monitored by two systems of monitoring stations. One system consists of nine stations which encircle the plant areas (figure 1) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of eight stations encircling the Oak Ridge area at distances of from 12 to 75 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur.

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average concentrations are presented in tables 1 and 2. Airborne radioactive iodine is monitored in the immediate environment of the plant areas by passing air through a cartridge containing activated charcoal.

During the January–June 1968 surveillance period, 206 samples were collected from perimeter monitoring stations and analyzed for iodine-131. Of these, the maximum concentration detected was 0.08 pCi/m^3, the minimum was less than 0.010 pCi/m^3, and the average was 0.01 pCi/m^3. The radiation protection standard specified in the AEC Manual for iodine-131 in the ambient atmosphere in uncontrolled areas is 100 pCi/m^3.

Milk monitoring

Raw milk is monitored for iodine-131 and strontium-90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge area. Four stations, located more remotely with respect to the Oak Ridge operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge area

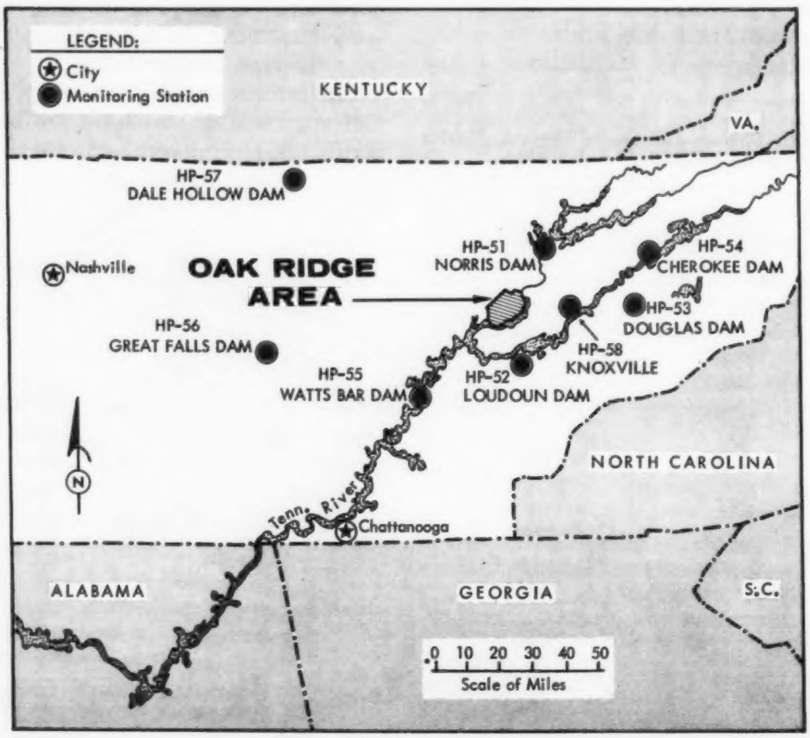

Figure 2. Remote air monitoring stations, Oak Ridge area

Table 1. Long-lived gross beta radioactivity of particulates in air, Oak Ridge area January–June 1968

Perimeter stations				Remote stations			
Station number (figure 1)	Number of samples	Average concentration (pCi/m^3)	Percent of AEC standard[a]	Station number (figure 2)	Number of samples	Average concentration (pCi/m^3)	Percent of AEC standard[a]
HP-31	26	0.21	0.21	HP-51	26	0.24	0.24
HP-32	26	.29	.29	HP-52	26	.22	.22
HP-33	26	.18	.18	HP-53	26	.21	.21
HP-34	26	.20	.20	HP-54	26	.20	.20
HP-35	26	.21	.21	HP-55	26	.16	.16
HP-36	182	.25	.25	HP-56	26	.25	.25
HP-37	26	.17	.17	HP-57	26	.22	.22
HP-38	26	.24	.24	HP-58	25	.25	.25
HP-39	26	.22	.22				
Average	----------	0.22	0.22	Average	----------	0.22	0.22

[a] The applicable AEC Radiation Protection Standard is 100 pCi/m^3.

Table 2. Long-lived gross alpha radioactivity of particulates in air, Oak Ridge area January–June 1968

Perimeter stations				Remote stations			
Station number (figure 1)	Number of samples	Average concentration (pCi/m^3)	Percent of AEC standard[a]	Station number (figure 2)	Number of samples	Average concentration (pCi/m^3)	Percent of AEC standard[a]
HP-31	26	0.002	0.10	HP-51	26	0.001	0.05
HP-32	26	.002	.10	HP-52	26	.001	.05
HP-33	26	.001	.05	HP-53	26	.001	.05
HP-34	26	.001	.05	HP-54	26	.001	.05
HP-35	26	.002	.10	HP-55	26	.001	.05
HP-36	182	.004	.20	HP-56	26	.001	.05
HP-37	26	.002	.10	HP-57	26	.002	.10
HP-38	26	.002	.10	HP-58	25	.002	.10
HP-39	26	.002	.10				
Average	----------	0.002	0.10	Average	----------	0.001	0.06

[a] The applicable AEC Radiation Protection Standard for natural uranium in air is 2 pCi/m^3.

provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples. The concentrations of iodine-131 and strontium-90 detected in raw milk samples during the period are given in table 3.

Table 3. Radionuclides in raw milk, Oak Ridge area January–June 1968

Radionuclide and location	Concentration (pCi/liter)		
	Maximum	Minimum[a]	Average
Iodine-131:			
Immediate environs	54	<10	6.7
Remote environs	<10	<10	5.0
Strontium-90:			
Immediate environs	50	5.0	21
Remote environs	34	14	20

[a] The minimum detectable concentrations of iodine-131 and strontium-90 in milk are 10 pCi/liter and 2 pCi/liter, respectively. In averaging, one-half of the minimum detectable concentration was used for all samples showing a radioactivity less than this concentration.

Water monitoring

Large volume, low-level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River system by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and Y-12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with AEC radiation protection standards. The radioactivity concentration from White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tenn. Stream gauging operations are carried on continuously to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta particle emitters, uranium, and the transuranic alpha-particle emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold up time in the waste effluent system are such that short-lived radionuclides are normally not present. The average concentrations of major radionuclides in the Clinch River are given in table 4 for the period from January through June 1968.

One composite water sample from the Clinch River was analyzed for uranium during this period. For this sample, the uranium concentration was less than 1 pCi/liter, the level of detectability. The AEC radiation protection standard for natural uranium in water released to unrestricted areas is 2×10^4 pCi/liter.

Table 4. Concentration of major radionuclides in the Clinch River, January–June 1968

Radionuclide	Concentration (pCi/liter)		
	Location on Clinch River[a]		
	Mile 23.1[b] (Upstream)	Mile 20.8[c] (Outfall)	Mile 4.5 (Downstream)
Strontium-90	0.4	1.1	2.0
Cerium-144	.3	<.1	0.4
Cesium-137	ND	.4	1.4
Ruthenium-106	.9	.3	1.0
Cobalt-60	ND	.5	1.1
Zirconium-niobium-95	ND	.2	.3
Gross beta	1.6	21.0	6.2

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River. See figure 1.
[b] Sampling station moved from Clinch River mile 41.5 to Melton Hill Dam CRM 23.1 about January 1, 1966.
[c] The concentrations at mile 20.8 are not measured directly but the values are calculated based on the levels of waste released and the dilution provided by the river.
ND, nondetectable.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above the ground. The results are shown in table 5 in terms of mR/hr.

Discussion of data

The average air contamination levels for gross beta radioactivity as shown by the continuous air monitoring filter data, for both the immediate and remote environs of the plants (figures 1 and 2) was 0.22 percent of the maximum permissible concentration applicable to uncontrolled areas.

Table 5. External gamma radiation levels[a] Oak Ridge area, January–June 1968

Location	Average dose rates (mR/hr)
Solway Gate	0.011
Y-12, East Portal	.011
Newcomb Road	.012
Gallaher Gate	.012
White Wing Gate	.010
Five locations	0.011

[a] The background in the Oak Ridge area, determined in 1954, was approximately 0.012 mR/hr.

The average air contamination levels for gross alpha radioactivity as shown by the continuous air monitoring filter data, for the immediate and remote environs of the plants were 0.10 percent and 0.06 percent, respectively, of the AEC radiation protection standard for natural uranium which applies to populations in the neighborhood of a controlled area.

The average concentration of iodine-131 in air in the immediate environs of the plants was 0.010 pCi/m^3. This is approximately 0.01 percent of the AEC radiation standard for populations in the neighborhood of a controlled area.

The average concentrations of iodine-131 in raw milk in the immediate and remote environs of the Oak Ridge area were 6.7 pCi/liter and 5.0 pCi/liter, respectively. These levels fall within the limits of FRC Range I if the average intake per individual is assumed to be 1 liter of milk per day.

The average concentrations of strontium-90 in raw milk in both the immediate and remote environs of the controlled area was approximately 21 pCi/liter. This level falls near the lower limit of FRC Range II for transient rates of daily intake of strontium-90 for application to the average of suitable samples of an exposed population.

The calculated average concentration of gross beta radioactivity in the Clinch River at mile 20.8 (the point of entry of most of the wastes) and the measured average concentration at mile 4.5 (near Kingston, Tenn.) were 21 pCi/liter and 6.2 pCi/liter, respectively. These values are 1.4 percent and 0.70 percent of the weighted average AEC radiation protection standards. The average concentration of transuranic alpha-particle emitters in the Clinch River at mile 20.8 was 0.023 pCi/liter which is approximately 0.01 per-

cent of the weighted average AEC radiation protection standard.

The average radioactivity of natural uranium materials in the Clinch River, reflecting the effects of all Oak Ridge plants, was less than 0.01 percent of the AEC radiation protection standard for natural uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge area was 0.011 mR/hr, which is approximately the same as that level measured during the period prior to Oak Ridge operations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1967	July 1968
July–December 1967	October 1968

2. Rocky Flats Plant[3]
July-December 1968

Dow Chemical Company
Golden, Colo

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location, relative to population centers, is shown in figure 3. To assure properly controlled releases of radioactive materials to the environment, periodic samples of air, water, and vegetation are analyzed for gross alpha radioactivity. The most abundant radioactive material involved in the process is plutonium.

The plant is located about 15 miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized front range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

[3] Summarized from "Environmental Survey, July–December 1968," The Dow Chemical Company, Rocky Flats Division, Golden, Colo.

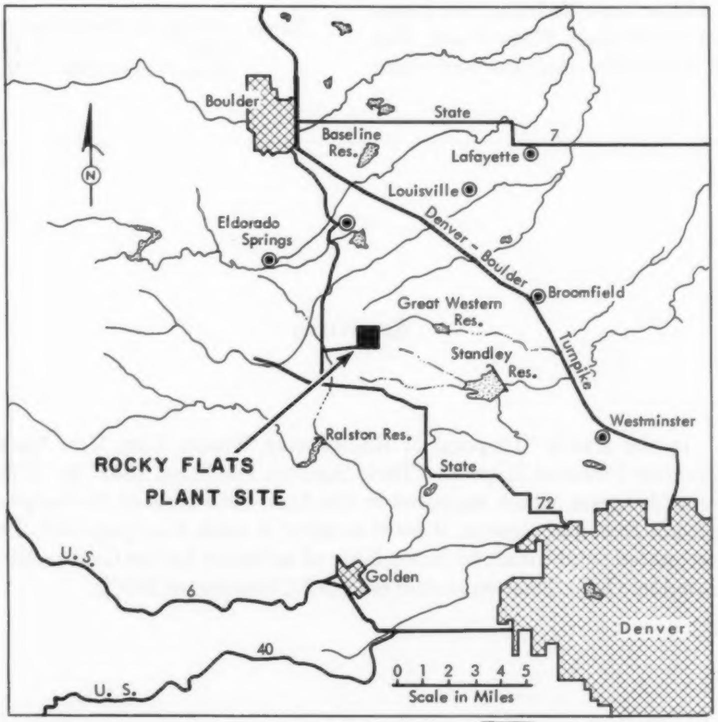

Figure 3. Rocky Flats Plant and environs near Denver, Colorado

Air

Continuous air samples were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner School, Golden, Denver, and Westminster. The monthly average long-lived gross alpha radioactivity shown in table 6 are believed to result from naturally occurring materials. All values are less than the AEC standard of 0.04 pCi/m^3 for mixtures of unidentified radionuclides.

Table 6. Long-lived gross alpha radioactivity in airborne particulates, RFP environs July–December 1968

Period (1968)	Average concentration (pCi/m^3)
July	0.5×10^{-2}
August	$.5\times10^{-2}$
September	$.6\times10^{-2}$
October	$.7\times10^{-2}$
November	$.4\times10^{-2}$
December	$.7\times10^{-2}$

Water

Regular water samples were obtained monthly except during the winter months from four reservoirs in the area of the Rockly Flats Plant. The results of alpha radioactivity analyses performed on these samples are given in table 7. For comparison purposes, the AEC standard for mixtures of unidentified radionuclides in water is 10 pCi/liter.

Table 7. Alpha radioactivity in water, RFP environs July–December 1968

Reservoir	Number of samples	Average concentration (pCi/liter)
Great Western	4	1.4
Standley	4	1.5
Baseline	4	0.9
Ralston	4	2.8

Vegetation

Vegetation samples collected in 1968 have been stored for analysis at a later date. A summary of these results will be included in subsequent reports.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	November 1968

Erratum

In the article "Disposal of Radioactive Wastes from U.S. Naval Nuclear-Powered Ships and Their Support Facilities, 1967" by Miles and Mangeno, which appeared in the April 1969 issue of *Radiological Health Data and Reports*, there is an error in table 3 on page 137. The estimated total cobalt-60 in top layer of sediment for the Groton-New London, Conn. location should read 0.2 Ci instead of 2.0 Ci.

Reported Nuclear Detonations, May 1969

The U.S. Atomic Energy Commission announced that a nuclear test of low-intermediate yield (20–200 kilotons TNT equivalent) was conducted underground on May 7, 1969 by the Atomic Energy Commission at its Nevada Test Site.

On May 16, 1969, the United States recorded seismic signals which originated from the Soviet nuclear test area in the Semipalatinsk region. The signals were equivalent to those of a nuclear test in the low-intermediate yield range (20–200 kilotons TNT equivalent).

Announcement was also made by the U.S. Atomic Energy Commission of a nuclear test of low-intermediate yield (20–200 kilotons TNT equivalent) conducted underground at its Nevada Test Site on May 27, 1969.

Seismic signals originating from the Soviet underground nuclear test area in the Semipalatinsk region were recorded by the United States on May 31, 1969. The signals were equivalent to those of a nuclear test in the low yield (less than 20 kilotons TNT equivalent).

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

PRELIMINARY RESULTS OF SURVEYS OF 5,263 MEDICAL X-RAY FACILITIES, 1962-1967. *Bureau of Radiological Health. Radiological Health Data and Reports, Vol. 10,* June 1969, pp. 235–246.

Preliminary results of State surveys of 5,263 facilities with medical x-ray equipment are presented. Parameters such as equipment type and operating characteristics, personnel protection, workload, and certain aspects of operating technique were studied over a period from 1962 to 1967. The results of these studies will be considered together with other studies now in preparation and it is possible that some of the findings will be changed when the data are further evaluated for reporting to Congress under Public Law 90-602.

KEYWORDS: Collimation, filtration, fluoroscopic machines, healing arts, Radiographic machines, survey, United States, x-ray.

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June 1969

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